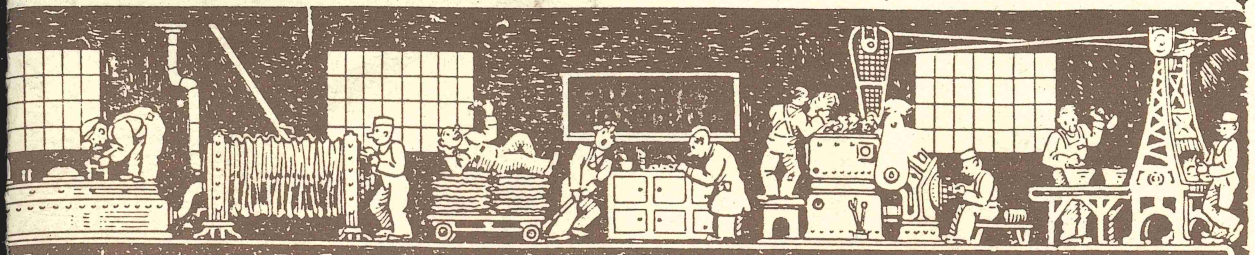
PORCELAIN BODY · ANOTHER INSPECTION • PUGGING, PLUNGING AND THEN



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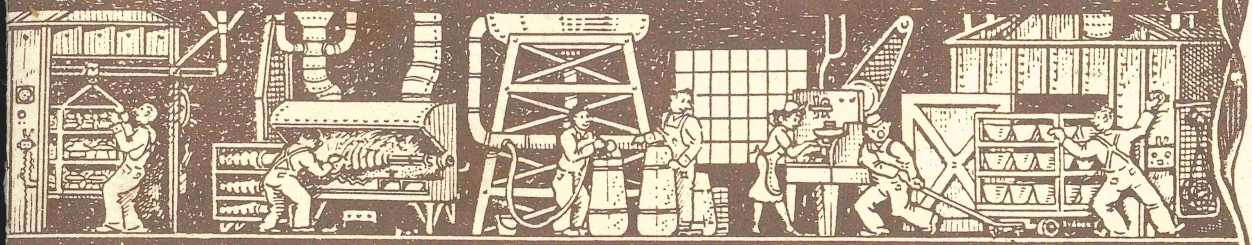
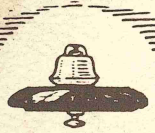
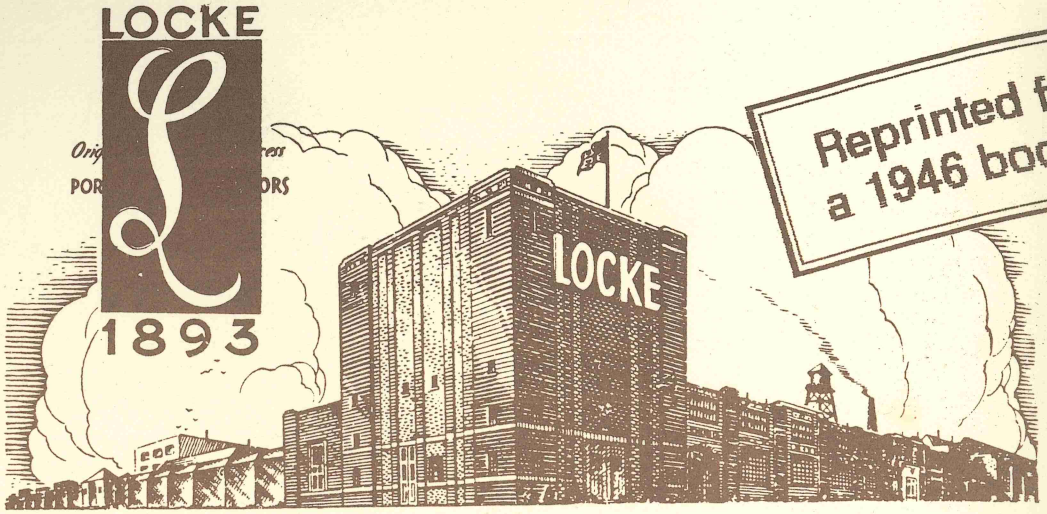


• ASSEMBLING • FINAL INPECTION • TESTING IN LAB. • PACKING AND SHIPPING • →

Birth of a LOCKE INSULATOR



Locke Insulators
OPEN HOUSE-PLANT TOUR
August 6, 1988
Baltimore, Maryland, U.S.A.



Let's Look at Locke...

You are a welcome visitor to the plant of the Locke Insulator Corporation--the world's largest manufacturer of wet-process porcelain insulators.

Our company was founded in 1893 in Victor, New York, by Fred M. Locke. Mr. Locke was a telegraph operator on the New York Central Railroad. He conceived and developed the first wet-process porcelain insulator because of the difficulties that he personally experienced with the insulators then in use on telegraph lines.

From a small beginning in 1893 has grown a whole industry that is fundamental in making possible the safe and economical transmission and distribution of electric power. With the advent of the high-voltage transmission line around the turn of the century came a big problem--insulators that would stand such high electrical stresses and yet were strong and reliable. Mr. Locke's insulators proved to be the answer. In fact, it is the only material manufactured today for such use.

Our company's only plant was in Victor until 1920 when the Baltimore plant was started. From 1920 until 1935 both plants were operated. In 1935, the plant at Victor was abandoned and all manufacturing was taken over by Baltimore.

[Continued on inside-back cover

Welcome to

THE LOCKE INSULATOR COMPANY

OPEN HOUSE & PLANT TOUR

"It is a great pleasure to welcome Locke retirees, employees, and family members to visit our facility. Here you will be able to see why my Locke co-workers and I are proud of the over 2,000 products manufactured here in Baltimore. These electrical insulators and other porcelain products are used throughout the North American continent and in many countries of the world.

"All of us are engaged in a difficult struggle to help Locke become the Success Story of Maryland. If, in each job, we apply dedicated determination, willing cooperation, and skilled experience, I feel certain that we will make it happen. Such confidence can be greatly strengthened by the support and understanding of the members of our respective families. Thank you for coming to visit with us."

--Gus Isobe, President

FOR YOUR INFORMATION: Do you know that...

...Locke Insulators provides, as the following paragraphs detail, a flow of millions of dollars into the economy of greater Baltimore and the State of Maryland, helping to create jobs for hundreds of other Marylanders.

...to run the kilns and other equipment, last year Locke spent nearly one million dollars ($968,840) for natural gas.

...the over 2,000 Locke products range from a list price of $3.00 to over $3,000 each.

...Locke's electrical bill for 1987 was over a half million dollars ($575,302).

...we used 75,954,164 gallons of water last year costing over $26,000.

...Locke's 1987 and projected 1988 tax bills from the City of Baltimore and State of Maryland will total over $344,000.

...Locke ships its products to all 50 of the United States, plus Puerto Rico, and, through the cooperation of NGK, to over 11 countries.

...the total 1987 and projected 1988 payroll for Locke employees will be about $23,745,000.

...the Locke facility is under nearly 20 acres of 123 separate major roofs; to re-roof the entire area would cost an estimated $5 to 6 million. In roof maintenance alone, Locke spends $300 to $350 thousand each year.

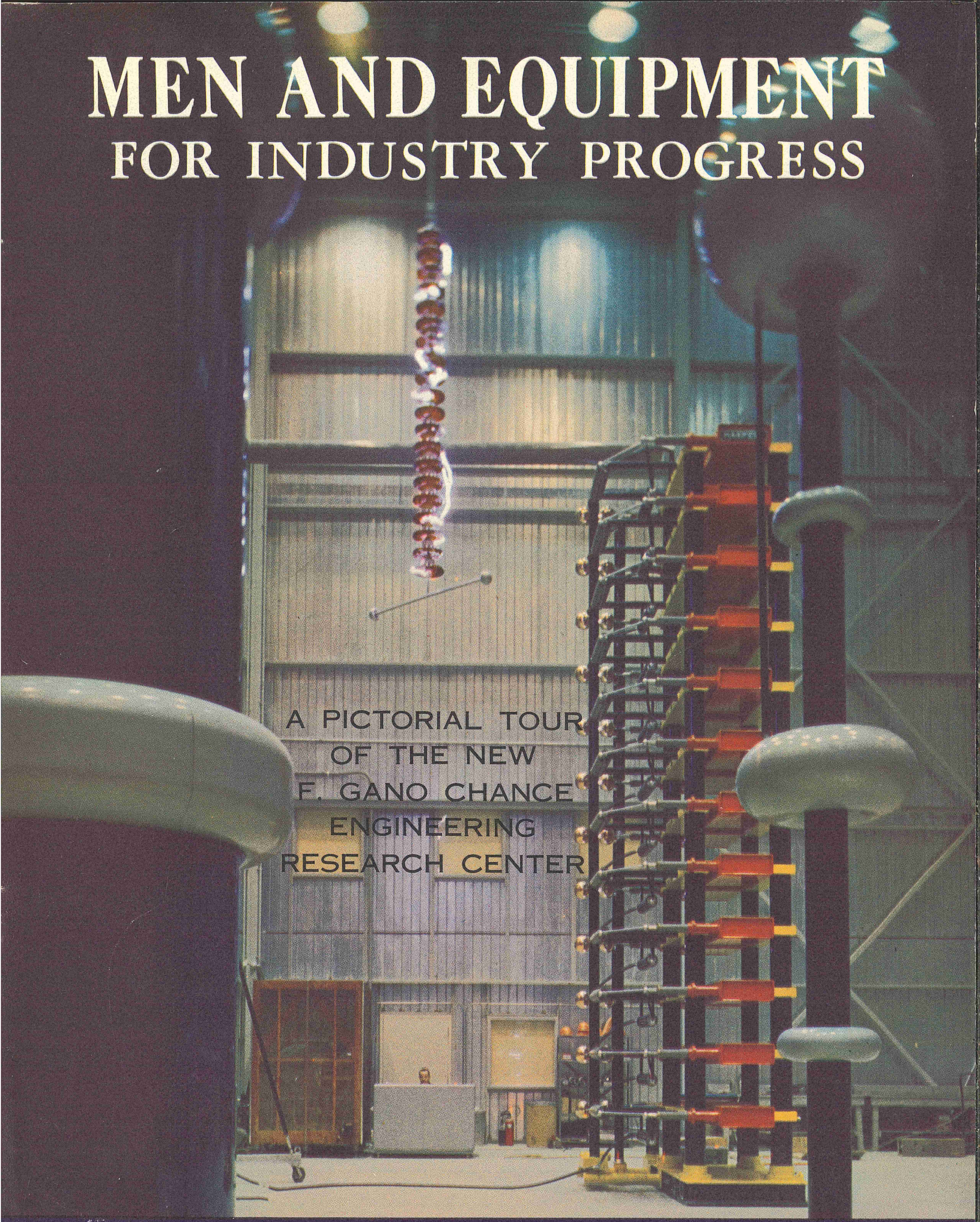
...the cost of health care, insurance, and other benefits for Locke employees and their families during last year and projected for this year will amount to over $8,243,000.

...two of Locke's tunnel kilns are about 400 feet long with firing temperatures as high as 2300 degrees Fahrenheit.

...the grand total figure for 1987 and projected 1988 salaries, wages, and benefits paid by Locke will amount to nearly $32,000,000.

Locke Insulators, Baltimore, Maryland, USA

MEN AND EQUIPMENT
FOR INDUSTRY PROGRESS



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CHANCE TIPS

SPECIAL RESEARCH ISSUE
VOL. 23 NO. 3

LOCKE INCORPORATED
Baltimore, Maryland

TECHNICAL REPORT NO. 546
May 23, 1949

SUBJECT

OHIO BRASS COMPANY SUSPENSION INSULATORS

This report contains:
4 Typewritten copies

Signed: J M Jesatko

Approved: [signature]

MAGNETIC HEATING OF TRANSMISSION LINE CLAMPS

BY: MESSRS. V. L. CRABB AND J. M. SHEADEL 49-212

Retold To R. L. McCoy

Schenectady, August 4, 1949

Mr. W. J. McLachlan
BUILDING 2

Herewith is a copy of the above A.I.E.E. Paper which is to be presented at the Pacific General Meeting at San Francisco, Calif., August 23-26, 1949. I assume that you will be interested in this subject and may wish to arrange for preparation of discussion.

All discussions must be approved through the regular channels before being submitted in triplicate to A.I.E.E. Headquarter. It will be advisable to prepare an additional copy to be handed to the representative of ELECTRICAL WORLD who will be in attendance at the meeting.

By copy of this letter to the individuals listed below I am asking that they also endeavor to arrange for preparation of discussion.

F. P. CALLAHAN

FPC:LL

cc: SB Crary, Bldg. 2
DL Beeman, Bldg. 2
CM Foust, Bldg. 37
ED Hoy, Pittsfield
WS Hill, Locke, Inc.
GB Shanklin, Bridgeport

AIEE
Technical Paper
49-212

July 1949
Litho in USA

MAGNETIC HEATING OF TRANSMISSION LINE CLAMPS

V. L. Crabb
Member AIEE

J. M. Sheadel
Associate AIEE

Both of:
The Ohio Brass Company
Barberton, Ohio

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A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, San Francisco, Calif., August 23-26, 1949. Manuscript submitted May 23, 1949; made available for printing June 30, 1949.

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60¢ To Nonmembers

AIEE
Technical Paper
53-81

December 1952
Litho in USA

Discussion for publication

must be postmarked on or before

February 4, 1953.

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REAL POWER AND IMAGINARY POWER IN ALTERNATING CURRENT CIRCUITS

C. F. Estwick
Member AIEE
43 Cambridge Place
Brooklyn, N. Y.

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60¢ To Nonmembers first class mailing desired)

Misc

MEASUREMENT OF EARTH RESISTANCES*

A.B. OSLON

Zlatoust

(Received 28 August 1955)

A three-electrode circuit is used to measure the resistances of an earthing system, these being: the earth electrode (earthing circuit), the current electrode and the potential electrode. All quantities referring to the earth electrode are denoted by the K, those referring to the current electrode by subscript T and those referring to the potential electrode by P.

Current is passed through the earth and current electrodes. The potential of the circuit is measured via the potential electrode. The earth resistance equals the measured potential divided by the current passing.

In Fig.1 the voltmeter and ammeter are instruments specially designed for measuring the resistances of earthing systems.

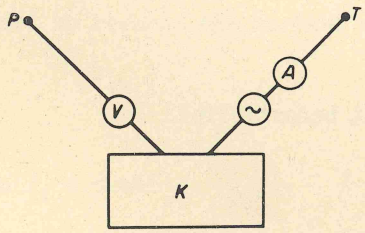

Fig. 1.

It is usually assumed that the current and earth electrodes must be sufficiently far apart not to distort the field and that a sufficiently large zero potential zone remains between them. The potential electrode must be placed in the zero potential zone [1,2].

Let us assume that we already know the earth resistance of the circuit R_K. Is it then possible, having placed the current electrode at an arbitrary point, to so locate the potential electrode that the measured resistance is equal to R_K? If this is possible, how can we determine the 'locus of precise measurements'?

To answer this question we will use the analogy between an electrostatic field and the field due to a current in a conducting medium.

* *Elektrichestvo* No. 2, 56–58 (1957). [Reprint Order No. EL. 10]

(5) The inter-turn voltages expected in travelling-wave tests can be calculated approximately from the machine winding data. As a rule, the test voltages will be sufficiently high in machines with few (two to four) turns per section.

REFERENCES

1. V.A. Karasev and Z.G. Kaganov; Wave propagation in the windings of electrical machines. *Elektrichestvo* No.4 (1949).
2. G.N. Petrov and A.I. Abramov; Inter-turn voltages in the windings of electrical machines during wave processes. *Elektrichestvo* No.7 (1954).
3. A.A. Timofeenko; Set-up for testing the inter-turn insulation of electric motors. *Elektricheskie Stantsii* No.6 (1950).
4. N.V. Smirnov; *Checking and Testing Windings in Electric Machines and Apparatus*. Gosenergoizdat, 1955.
5. N.V. Smirnov; Testing the turn insulation of electric motor windings under service conditions. *Elektrichestvo,* No. 5 (1955).
6. Deckans; Investigation of surges in H.V. motors. A.S.E. – Bull. No.35 (1953).
7. G.G. Shvets and S. Gretskii; Experimental investigation of surges in the windings of electric machines. *Electrical Insulation* No.2 (1938).
8. R.C. Robinson; Distribution of impulse voltages in bar-wound high-speed turbogenerators. *Proc.Instn.Elec. Engrs.* No.77 (1953).
9. A.P. Aleksandrov *et al.* *The Physics of Dielectrics.* G.T.T.I. (1932).

A METHOD OF DERIVING EQUATIONS FOR THE ELECTROMECHANICAL TRANSIENT IN ELECTRIC CIRCUITS*

S.V. STRAKHOV

(Received 5 October 1956)

There are basically two methods of investigating the transient electromechanical processes in electric circuits, viz:

1. Physical modelling.
2. Mathematical modelling, this comprising two sections, viz:
   (a) the section using physical analogs;
   (b) the section using digital computers (integrators) with continuous and discrete action.

The method of physical modelling, comprehensively treated in papers of V.A. Venikov [1-3], M.P. Kostenko [4-6] and of other authors, consists in the replacement of large rotating electric machines and hydraulic turbines by similar units of small ratings with due consideration to the laws of similitude. Transmission lines, tranformers, saturable reactors and static loads are replaced by assemblies of capacitances and inductances, networks with repeated members being used for transmission lines. In other words, in this case the physical character of the model and of the original are the same.

Among the advantages of the method of physical modelling, where rotating machines are concerned, we should mention the possibility of considering eddy currents, saturation, hysteresis, the actual distribution of stator and rotor windings in space, and of other factors. A drawback of this method is the difficulty of varying the parameters of individual machines, usually necessitating the availability of a number of inter-changeable rotors for them. It is, therefore, more convenient to use the method of mathematical modelling in cases where the parameters of the machines must be variable; because this method can deal in a much more simple way with such variations. However, physical modelling will still be preferable in all cases in which the system of differential equations describing the process is very complicated.

* *Elektrichestvo* No. 7, 5-10, 1957 [Reprint Order No. EL 32].

THE INDUCTION LAW FOR AN ELECTROSTATIC MACHINE*

A.A. BAL'CHITIS

(Received 19 December 1956)

Introduction

The fundamental equations of the classical theory of electrodynamics, the first and second equations of Maxwell point to two possible methods of conversion of mechanical into electrical energy. For example, by the first equation of Maxwell†

$$\operatorname{curl} \bar{H} = \gamma \bar{E} + \frac{\partial \bar{D}}{\partial t} \tag{1}$$

such a conversion is possible when an electric field changes with time, i.e. by mechanical action on the electric field it is possible to obtain the magnetic field connected with it in space.

According to the second equation

$$\operatorname{curl} \bar{E} = -\frac{\partial \bar{B}}{\partial t} \tag{2}$$

it is possible to obtain an electric field by changing the magnetic field associated with it.

The second equation of Maxwell was the generalized form of Faraday's experimental law of electromagnetic induction, viz.

$$E = B\, l\, v, \tag{3}$$

which was discovered in 1831 and forms the basis of the design of a large variety of electric machines, covered by the general term "electromagnetic machines".

Machines working on the principle of a mechanical change of an electric field (Maxwell's first equation) are not nearly so widely used; they are known as *electrostatic* machines. These machines are used for obtaining high and very high voltages for research purposes.

For a long time electrostatic machines did not find practical uses. The suc-

* *Elektrichestvo* No.7, 11 – 14, 1957 [Reprint Order No.EL33].

† All equations are given in terms of the absolute practical rationalized system of units.

Conference Paper

RESEARCH BY THE CENTRAL ELECTRICITY AUTHORITY

J. S. Forrest
Nonmember AIEE
Central Electricity Research Laboratories
Leatherhead, Surrey, England

Submitted in abstract or outline form only to the AIEE Committee on Research for the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Manuscript submitted November 29, 1955; made available for printing December 9, 1955.

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Paper No. CP
56-267

TELEVISION IN THE WORLD TODAY

by

Charles J. Hirsch
Hazeltine Corporation
Little Neck, L.I., N.Y.

A conference paper for presentation at Winter General Meeting of American Institute of Electrical Engineers, New York City, Thursday, February 2, 1956, at 9:30 A.M.

CP 56-354

WIND PRESSURE ON OVERHEAD TRANSMISSION LINE CONDUCTORS*

V.V. BURGSDORF

(Received 9 January 1957)

The correct assessment of wind pressure on conductors is of great importance in the design of transmission lines. This applies particularly to double-circuit lines and lines equipped with release clamps and safety (swivelling or collapsible) cross-arms, since in these cases there is an upper limit imposed for the maximum permissible wind loading. In designing large installations, it is necessary to know accurately the aerodynamic characteristics of conductors and the distribution of wind pressure.

As is well known, strong winds are always of turbulent nature and consist of fast-and slow-moving air masses. In other words, the wind velocity is never uniform along the front of a gust. The total load on a long object is therefore determined not by the maximum, but by some mean value, of the wind velocity. For spans longer than 200 m this lack of uniformity may be of considerable importance.

The first experimental investigations to ascertain the extent of the non-uniformity in the distribution of the wind velocities affecting the total load on conductors date back over 25 years [1] and [2]. These tests showed that for wind speeds up to 20 m/sec. this non-uniformity can be neglected for spans up to 100 m. long, but that it becomes sufficiently noticeable on spans about 200 m. long.

Later investigations carried out in Sweden in 1939 revealed a possibility of reducing the design value of wind load because of the finding that the wind pressure becomes less uniform with velocity [3]. Similar experiments were also carried out in other countries: France in 1951 [4] and [5], Australia in 1949 [6]; Belgium in 1952 [7]. Recently investigations were made in West Germany [8] and in the U.S.S.R. where eight experimental stations were erected with span lengths from 220 to 350 m.

The reduction co-efficient considering the non-uniform distribution of the pressure along the span was introduced in the Soviet Regulations for Trans-

* *Elektrichestvo* No.5, 47-52, 1957 [Reprint Order No. EL 23].

CORONA LOSSES ON LIVE TRANSMISSION LINES*

V.D. KRAVCHENKO, V.I. LEVITOV and V.I. POPKOV

(Received 7 February 1957)

The corona loss on an energized transmission line constitutes only a small fraction of the transmitted energy and is commensurable with or sometimes even smaller than the heat loss. Therefore, it is practically impossible to determine this loss by separating the current component which corresponds to the corona loss from the total line current as measured by conventional methods.

The corona loss is due to the cross currents, that is, the currents that flow between the conductors and between the conductors and earth. If it were possible to measure quantities which are proportional to these currents, or to their corresponding charges this would be the best solution of the problem of measuring the corona losses on energized lines.

Fig. 1 shows an arrangement consisting of a single phase-conductor, 1, and an aerial, 2, which is earthed through a measuring element Z connected to the middle of the aerial.

The e.m.f. induced electromagnetically in an aerial isolated from earth is so distributed that it is zero at the middle of the aerial [1]. Therefore, if this point is earthed through a measuring element Z, no current can flow in the element owing to the magnetic field of the line. The current which flows in the element is determined only by the electrostatic coupling between the line and the aerial.

The minimum height at which conductors are suspended on conventional lines is 7 – 8 m. At this height the space charge in the region G (Fig. 1) is distributed practically symmetrically with respect to the conductor axis, i.e. the space charge density depends only on the distance from the axis of the conductor of the element of charge considered. Consequently, the integrated electrostatic effect of the space charge on the aerial is the same as that of a linear charge of equal magnitude placed at the axis of the conductor.

For sufficiently small values of the impedance Z the relation between the charge on the aerial and the total charge of the conductor is given by:

$$\alpha_{12}q_1 + \alpha_{22}q_2 = 0 \qquad (1)$$

* *Elektrichestvo* No. 7, 31 – 34, 1957 [Reprint Order No. EL 35].

THE NOMOGRAM FOR DETERMINING PROTECTIVE ZONES OF LIGHTNING CONDUCTORS*

L.M. LOPSHITS

(Received 24 April 1956)

This nomogram supersedes an earlier one (*Elektrichestvo*, No. 10, 1947) and is deemed necessary because of the distinction made in the latest instruction book on overvoltage protection of electrical installations for 3 - 220 kV (Gosenergoizdat, 1954) between the formulae for lightning conductors up to and above 30 m.

The nomogram is constructed for single and double lightning conductors up to 150 m using an emphirical formula based on laboratory test results and on the assumption that orientation of the lightning stroke onto the lightning conductor takes place at the height of H = 600 m (for an open country).

The use of the nomogram is explained with three examples.

That part of the latest Code of Practice on protection against overvoltages [1] which deals with protection against direct lightning strokes is based on laboratory investigations carried out at the V.I. Lenin All Union Electro-technical Institute, and differs from the earlier edition of the Code [3] in that in it a distinction has been introduced between the formulae for rod lightning conductors up to 30 m high and above 30 m high. Thus, the earlier nomogram for determining protective zones, constructed for lightning conductors up to 60 m has become obsolete and now may be used only for lightning conductors up to 30 m.

Figs. 1 and 2 give curves constructed from the data included in [2] which describe protective zones of single and double lightning conductors respectively. The geometrical sense of the parameters of the protective zone a, h, ha, h_x, b_x, and r_x is clear from Fig. 4; by H is denoted the height at which orientation of the lightning channel onto the lightning conductor takes place for open country.

For taller lightning conductors, $h > 30$ m, H was taken as 600 m, and for shorter lightning conductors, $h < 30$ m, the constant ratio of $H/h = 600/30 = 20$ was taken. It should be mentioned here that the Code of Practice does not set definite limits within which its recommendations are valid but merely states that the value of $H = 600$ m can be used for "very tall lightning conductors".

The curves given in Figs. 1 and 2 can be applied in these cases when the height of the lightning conductor does not exceed 150 m ($H/h = 4$), which corres-

* *Elektrichestvo* No. 7, 76 – 78, 1957 [Reprint Order No. EL 39].

ARCING SHORT-CIRCUITS ON 400 kV TRANSMISSION LINES AND METHODS OF DEALING WITH THEM*

A.S. MAIKOPAR and N.N. BELIAKOV

Central Scientific and Research Electrotechnical Laboratory,
Moscow Electric Station

(Received 19 September 1957)

On 400 kV transmission lines with a solidly earthed neutral, we have to expect mainly single-phase short-circuits to earth. As opposed to the lines with lower voltages, the restoring of the electric strength of the path of the arc after switching off the phase becomes more difficult on 400 kV lines because of appreciable influence of the current at the point of damage caused by capacitive and electromagnetic connections between the disconnected phase and the working phases. The supply current which will flow at the point of the fault, after automatically switching off the faulty section of the line, will sustain the electric arc for a certain time. The next reclosing can be done only after the extinction of the arc and restoration of the electric strength. This circumstance not only defines the placing of protective relays but also exerts an influence on the total lay-out of switchgear on the 400 kV lines. In particular, the problem of connecting shunting reactors directly to the line or through the circuit-breakers is strictly connected with the extinguishing of the sustained current arc. Several works are known dealing with research on the sustained current arcs [1-5]. Nevertheless, they do not give a clear idea of the range of sustained currents, for which it is possible to use single-phase automatic reclosing. As a result of these works, it is assumed that the extinguishing of the sustained current arc is possible for the currents of the order of 12-15 A.

Research into powerful open arcs, carried out by the C.S.R.E.L., has shown that an electric arc is capable of self-extinction even for currents of a few hundred ampres, if the conditions exist for a substantial increase of its length [6]. On this basis the investigations of the sustained current conditions were undertaken. Experiments on a 6 kV model have shown that the extinction of the sustained current arc for gradients of 5-15 kV/m occurs for currents up to 75-100 A, and experiments on a 220 kV grid 750 km long have shown the possibility of

* *Electrichestvo* No.1, 19-25, 1958 [Reprint Order No. EL 43].

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District Conference Paper

UNBALANCED LOADING OF THREE-PHASE TRANSFORMER BANKS

S. W. Anderson
Associate Member AIEE
Middle West Service Company
Chicago, Ill.

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H. A. FREY

A paper recommended by the AIEE Committee on Transmission and Distribution for the AIEE Great Lakes District Meeting, Des Moines, Iowa, April 15-17, 1957. Manuscript submitted January 14, 1957; made available for printing March 14, 1957.

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Paper No. DP
57-608

INSULATOR DEPARTMENT

GENERAL ELECTRIC COMPANY

Baltimore, Maryland

Technical Report No. LK-647
May 28, 1958

SUBJECT

Knox 6 Inch, 10,000 lb. Suspension Insulator

This report contains:

3 Typewritten Pages

Signed Joseph Kaminski Jr Approved Fred C. Vose

F.C. Vose

GENERAL ELECTRIC COMPANY
INSULATOR DEPARTMENT
Baltimore, Maryland

Technical Report No. LK-646-DR

May 28, 1958

SUBJECT

Knox 10 Inch 15,000 Lb. Insulator

J. Kaminski, Jr.

This report contains:

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Misc.

Conference Paper

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J Kaminski
J M Jesatko
H C Rose
N J Walters
L J Stevens
R N Anderson
B E Kingsbury

POWER SYSTEM PLANNING ECONOMICS

A. J. Wood
Member AIEE
General Electric Company
Schenectady, N. Y.

A paper recommended by the AIEE System Engineering and Transmission and Distribution Committees for presentation at the AIEE Summer General Meeting and Air Transportation Conference, Buffalo, N. Y., June 22-27, 1958. Manuscript submitted January 31, 1958; made available for printing April 15, 1958.

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58-870

District Conference Paper

MAGNETIC LOOP CONTACTS FOR OUTDOOR GROUP-OPERATED SWITCHES

Eugene Gorin
Member AIEE
Memco Engineering & Mfg. Co., Inc.
Commack, L. I., N. Y.

A paper recommended by the AIEE Switchgear Committee for presentation at the AIEE Middle Eastern District Meeting, Baltimore, Md., May 19-21, 1959. Manuscript submitted March 12, 1959; made available for printing March 20, 1959.

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Paper No. DP
59-653

Transactions Paper

(Reviewed and Accepted for Publication)

ZERO-SEQUENCE CURRENT DENSITY IN THE EARTH

Marion E. Forsman
Member AIEE
University of Florida
Gainesville, Fla.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer and Pacific General Meeting and Air Transportation Conference, Seattle, Wash., June 21-26, 1959. Manuscript submitted July 29, 1955; made available for printing May 1, 1959.

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Discussion in Duplicate Due July 10, 1959.

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CRITICAL-PATH PLANNING AND SCHEDULING

A SUMMARY

by

J. E. Kelley, Jr.

and

Morgan R. Walker

Mauchly Associates, Inc.

Ambler, Pa.

May 1960

misc.

Conference Paper

VOLTAGE NOMENCLATURE - SECONDARY AND UTILIZATION SYSTEMS

A. S. Anderson
Fellow AIEE
Ebasco Services Inc.
New York, N. Y.

A paper recommended by the AIEE Transmission and Distribution Committee for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 19-24, 1960. Manuscript submitted March 22, 1960; made available for printing May 4, 1960.

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Paper No. CP
60-842

B. Kingsbury
Ins - Dielectrics

GENERAL ELECTRIC COMPANY

INSULATOR DEPARTMENT

Technical Report No. LK-183-CR

July 22, 1960

SUBJECT

THEORETICAL MODEL FOR VOLTAGE STRESS AND PUNCTURE STRENGTH OF PORCELAIN DIELECTRIC PLATES

Ronald H. Lester

INFORMATION CONTAINED IN
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This report contains:

8 typewritten pages

Baltimore, Maryland

Signed Ronald H. Lester

Approved P. B. Horton

Mr Weller
Misc.

Conference Paper

THE USE OF THE ELECTROLYTIC TANK FOR DETERMINING EXTERNAL INDUCTANCES OF ENCLOSED CONDUCTORS

L. L. Mankoff
Associate Member AIEE

R. H. Brealey, Jr.
Nonmember AIEE

Both of:
General Electric Co.
Philadelphia, Pa.

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Paper No. CP
60-176

District Conference Paper

Music

MEASUREMENT OF FLICKER RESULTING FROM LARGE ARC FURNACE OPERATIONS

D. E. Simmons
Associate Member AIEE
Houston Lighting and Power Co.,
Houston, Tex.

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Paper No. DP
60-517

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GENERAL ELECTRIC COMPANY

INSULATOR DEPARTMENT

Technical Report LK-694-DR

October 10, 1961

Subject:

NINE INCH SUSPENSION INSULATOR E1763

J. Kaminski, Jr.

This report contains:

6 typewritten pages

Baltimore, Maryland

Signed Joseph Kaminski Jr. Approved Fred C. Vose

HIGH LINE TOOLS

FOR HIGH VOLTAGE LINES

AND HEAVY CONDUCTORS

PAST, PRESENT AND FUTURE

by

CLETUS R. BREWER
Chief Hot Line Tool Demonstrator
James R. Kearney Corporation
St. Louis, Missouri

Presented At:

Pacific Coast Electrical Association
Engineering and Operating Meeting
Overhead Transmission and Distribution Group

March 23, 1962

San Francisco, California

Transactions Paper

(Reviewed and Accepted for Publication)

RAINFALL RATE AND RESISTIVITY AT EAST PITTSBURGH, PA.

D. L. Whitehead
Fellow AIEE
Westinghouse Electric Corp.
East Pittsburgh, Pa.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Denver, Colo., June 17-22, 1962. Manuscript submitted November 24, 1961; made available for printing March 29, 1962.

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Paper No.
62-1025

Discussion in Duplicate Due July 6, 1962.

Conference Paper

HIGH SPEED THREE POLE RECLOSING

Report of the Arc Deionization Times Working Group

of the AIEE General Systems Subcommittee

For presentation at the AIEE Summer General Meeting, Denver, Colorado, June 17-22, 1962.

Arc Deionization Times Working Group: H. M. Ellis, Chairman; O. A. Demuth, L. O. Barthold, A. E. Kilgour, D. F. Shankle, W. Watson, E. T. B. Gross, R. E. Stade.

Paper No. CP
62-1316

Conference Paper

ELECTROMAGNETIC AND ELECTROSTATIC TRANSMISSION LINE PARAMETERS BY DIGITAL COMPUTER

M. H. Hesse
Member AIEE
Electric Utility Analytical Engineering
General Electric Company
Schenectady, N.Y.

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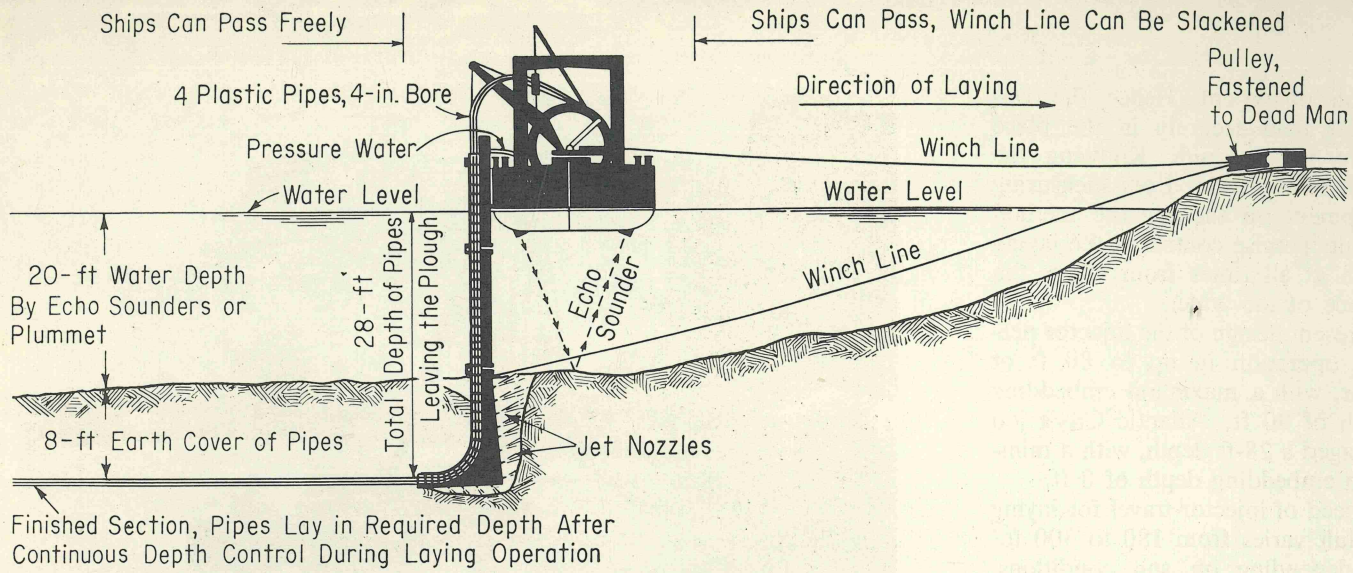
Paper No. CP
62-1387



Conduits 'Hydro-Jet' Embedded for 750-Ft River Crossing

High density polyethylene conduit for 69-kv cable is currently being jet-embedded 8-ft below the bottom surface of Beach Thorofare waterway at Atlantic City Electric Co. A novel "hydro-jet" method of embedding the conduit is being employed for the job by the job-contractor, Harmstorf Corp, Larchmont, NY.

The project involves a distance of 750-ft at the point of waterway crossing. Four, 4-in. I.D. high density polyethylene conduits (0.45-in. wall thickness) have been jet-laid to date. Sixteen of them will eventually be installed in four separate cuts.

In contrast to conventional methods used in laying underwater conductor conduit or cable, the hydro-jet method does not require removal of soil with a dredge and its subsequent replacement, is not subject to "filling-in" (as in a dredged-trench) before the conduit or cable is laid: and, the method does not rely on the skill and physical stamina of divers. Furthermore, and of significance is the basic advantage of being able to efficiently and economically embed conduit under the river bottom.

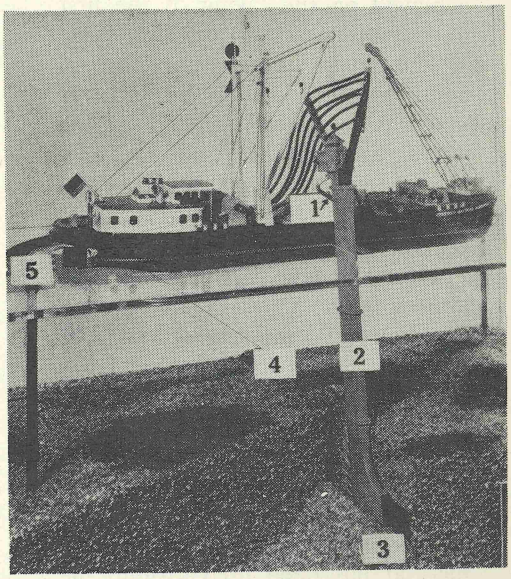
The use of "buried" plastic conduits to house the cable permits the use of more flexible, less expensive unarmored cable. Also, spare conduits can be buried at the time of installation, so that additional cables can be pulled through the spare conduits at a later date when service is expanded. Idle investment in spare conduits is low. Removal of cable for repair or replacement is simple.

Cable embedding begins with the "hydro-jetter" equipment positioned just outside the "near-shore" sheet piling; with winch-control lines rigged from both the near and far shore; and, with the four-conduit lines threaded from its source coil around the outboard side of the tug and down through the injector housing and conduit guide section.

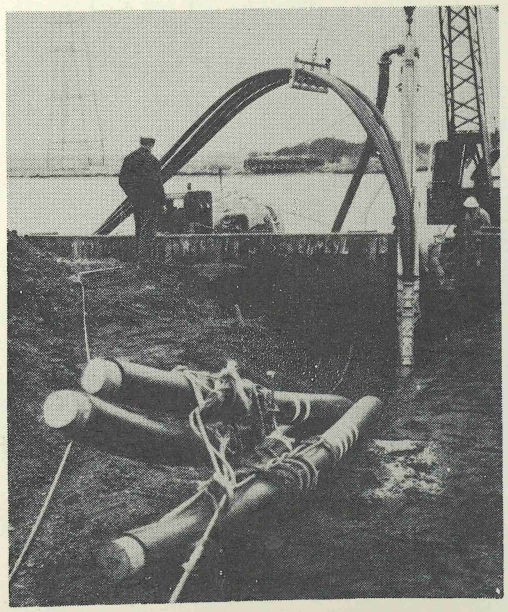
The essential part of equipment required for hydro-jetting is the injector. It includes a high-pressure water section and a conduit guide section. At the leading narrow edge of the injector, in the direction of travel, and at its bottom, water jets are provided.

As the injection jets are pressurized to about 170 psi, a narrow cut of controllable depth is made into the bottom of the body of water and the conduit is simultaneously laid along the bottom of the cut—the winch lines from the far shore move the "hydro-jetter" along its laying route.

This bottom "trench" is produced primarily by the action of high-power water jets. The soil loosened by the jets, temporarily in suspension in the surrounding water, settles rapidly and immediately starts to embed the conduit laid along the



HYDRO-JETTER UNIT: 1-water-pressure hose; 2-injector; 3-plastic conduit to be embedded in river bottom; 4-winch line; 5-free-running conduit coils



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Fundamental Aspects of Some Switching Overvoltages on Power Systems

J. ZABORSZKY
FELLOW AIEE

J. W. RITTENHOUSE
FELLOW AIEE

Summary: System overvoltages caused by switching are of interest in insulation coordination problems. This paper treats such overvoltages in a graphical fashion, so that a visual concept of overvoltage versus time is provided in both single- and 3-phase cases involving resistive loads, inductive loads, and capacitive loads. As special cases, attention is given to a neutral inversion problem and to a case of coupled circuits.

THE INCREASING complexity of power systems has created difficulty in analyzing specific cases of trouble which seem to stem from system overvoltages. It is believed that some of this difficulty can be minimized if one has a thorough grasp of the causes of overvoltages.

It is the purpose of this paper to demonstrate and review a few of the fundamental conditions that can cause overvoltages. In particular, overvoltages arising from switching operations will be discussed.

It is believed that the graphical approach that is followed provides an easy means of conducting a review in providing a good physical concept of the basic causes of many kinds of overvoltage phenomena.

Restrikes in a Single-Phase Resistive Circuit

A single-phase radially fed pure resistive load is shown in Fig. 1. The line itself is assumed to be purely resistive, and while this is admittedly not a practical combination, it is included here as an introduction to practical but more complicated situations which will be dealt with later.

Current is interrupted at time t_1; prior to that there is a voltage drop, with a peak value of ΔE, on the line. This, for the resistive circuit shown, is exactly in phase with the current, I, which in turn is exactly in phase with the source voltage E_α. Following current interruption at t_1, the voltage E_a remains zero, while the source end of the switch follows the source voltage $E_A = E_\alpha$.

The difference between the E_A and E_a curves, $E_a - E_A$, is the recovery voltage which is being built up across the gap of the switch.

If at some time after t_1 the recovery voltage exceeds the dielectric strength between the switch contacts, a restrike will occur. The potentially most dangerous time for this is t_2 when the peak recovery voltage is reached. Nothing unpleasant happens, however, in this purely resistive circuit. The current is re-established, and it instantaneously assumes the value it would have had at the instant of restrike if there had been no interruption.

The voltages of the terminals a and A instantaneously shift to satisfy the condition $E_A = E_a$ which would have existed with the load connected and if no interruption had occurred.

Restrikes in a 3-Phase Resistive Circuit

Conditions for the 3-phase purely resistive circuits are shown in Fig. 2. The line resistances have been omitted in this illustration to keep it as uncluttered as possible.

Current (not shown) in phase A is interrupted at time t_a. From here on $E_a = E_n$, and since n now is simply the midpoint of a voltage divider between points b and c, also $E_a = (E_b + E_c)/2$.

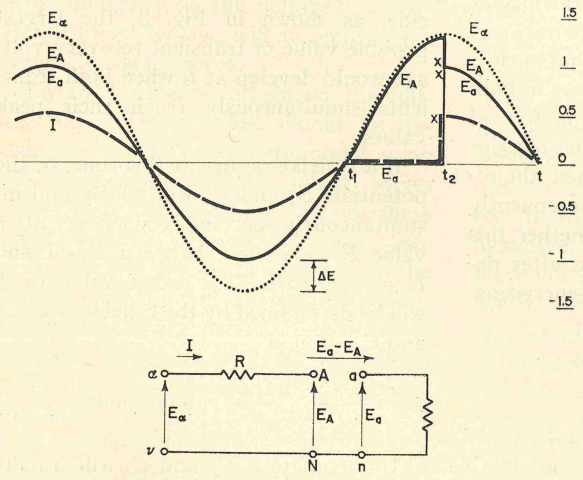

Fig. 1. Circuit, voltages, and current considered in the single-phase resistive restrike and energizing cases (left)

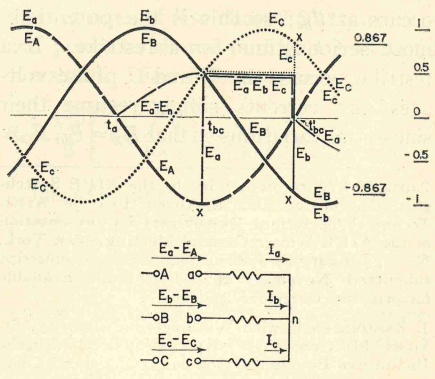

Fig. 2. Circuit and voltages considered in the 3-phase resistive restrike and energizing cases (right)

Transactions Paper

(Reviewed and Accepted for Publication)

Discussion in Duplicate Due July 5, 1963.

ARC DEIONIZATION TIMES ON HIGH SPEED THREE POLE RECLOSING

IEEE Working Group on Arc Deionization Times
of the
General Systems Subcommittee
of the
IEEE Transmission and Distribution Committee

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Members of the IEEE Working Group on Arc Deionization Times of the General Systems Subcommittee: H. M. Ellis, Chairman; O. A. Demuth, L. O. Barthold, A. E. Kilgour, D. F. Shankle, E. T. B. Gross, R. E. Stade.

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Paper No.
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REA Bulletin 61-7
OCTOBER 1964

TRANSVERSE LOADING of PIN TYPE INSULATORS

RURAL ELECTRIFICATION ADMINISTRATION * U.S. DEPARTMENT OF AGRICULTURE

GENERAL ELECTRIC
ELECTRIC UTILITY ENGINEERING
OPERATION

MAIL ADDRESS:
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Schenectady, N.Y.
June 9, 1965

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SUBJECT

ELECTRIFICACION DEL CARONI, C.A.
400-KV Tower Insulation Design
Study

Messrs. Kaminski
~~Kingsbury~~

Please return to M.A.S. for file.

~~Miss Mary Stack~~
2525 Insulator Drive
BALTIMORE

Dear Miss Stack:

A copy of this report has been mailed to R. E. Bauer in accordance with his request. This was a customer study and the results are proprietary to General Electric Company.

R. L. Thompson

R. L. Thompson
Application Engineer
A-C Transmission Engineering
Building 2 - Room 610 - Dial Comm 8*235-3657

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Encl.

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ELECTRIFICACION DEL CARONI, C.A.

400-KV TOWER INSULATION

DESIGN STUDY

May 4, 1965

L. O. Barthold
R. L. Thompson

General Electric Company
Schenectady, New York

IEEE SUMMER POWER MEETING

JUNE 22-27, 1969
DALLAS, TEXAS

DALLAS TOUR

9:00 a.m. - 12:00 Noon
Wednesday, June 25, 1969

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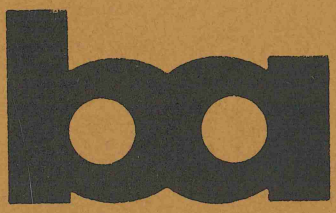

CONTRACT BOOK
FOR THE PROCUREMENT OF

1000 V DC CONTACT RAIL ASSEMBLY AND CURRENT COLLECTORS

CONTRACT No. 2Z1014
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Reprint GE Review	EFFECTO OF SHORT LENGTHS OF CABLE ON TRAVELING WAVES	McEachron, KB Hemstreet, JG Seelye, HP	General Electric Schenectady, NY	Nov. 1930
Paper	A HYPOTHESIS CONCERNING LIGHTNING PHENOMENA AND TRANSMISSION LINE FLASHOVER	Johnson, IB Schultz, AJ	General Electric AIEE Members	
Paper	ANALYTICAL STUDIES ON LIGHTNING PHENOMENA INVOLVING TOWERS, INSULATOR STRINGS, AND TRAMISSION LINES	Johnson, IB Schultz, AJ	General Electric AIEE Members	
AIEE 50-163	A METHOD OF ESTIMATING LIGHTNING PERFORMANCE OF TRANMISSION LINES	AIEE Working Group	AIEE	May 1950
AIEE 55-475	TRAVELING WAVE PROTECTION PROBLEMS - II	Boehne, EW	MIT Cambridge, MA	June 20, 1955
Minutes Memorandum	AMERICAN GAS & ELECTRIC FLASHOVER PROBLEM FIELD STUDIES-SURGE CHARACTERISTICS OF 300 kV TOWERS	Johnson, IB	General Electric	Aug. 31, 1956
Electrical World	WHY EHV LINES SHOW EXCESS OUTAGES	Millers, CJ Jr.	Ohio Brass Co. Barberton, OH	Sept. 5, 1955
AIEE 56-733	A NEW APPROACH TO THE CALCULATION OF THE LIGHTNING PERFORMANCE OF TRANMISSION LINES	Wagner, CF	Westinghouse E. Pittsburgh, PA	March 28, 1956
Paper	PRINCIPLES FOR THE CALCULATION OF THE LIGHTNING PERFORMANCE OF A TRANSMISSION LINE FOR A DIRECT LIGHTNING STROKE TO THE LINE	Lundholm, Ragnar	Sweden	1956
Letter to IB Johnson	Re. Prof. Lundholm's paper	Skeats, WF	General Electric Philadelphia, PA	Nov. 26, 1956
Comments to Skeats Letter	re: Prof. Lunholm's paper	Lundholm, R per Finn, RB Jr.	Am. GAs & Electric New York	Dec. 12, 1956
Booklet	INDUCED OVERVOLTAGE-SURGES ON TRANSMISSION LINES AND THEIR BEARING ON THE LIGHTNING PERFORMANCE AT MEDIUM VOLTAGE NETWORKS	Lundholm, R.	Gothenburg, Sweden	1957

Number	Title	Author	Company	Date
Report 57TP150	THEORY AND MODEL TESTS OF LIGHTNING VOLTAGES ON TRANSMISSION LINES	Anderson, JG	General Electric Pittsfield, MA	Jan. 2, 1957
Paper	LIGHTNING FLASH COUNTER	Cawkell, AE	Middlesex, England	April 1957
DP 57-537	CALCULATION OF TRANSMISSION LINE LIGHTNING VOLTAGES BY FIELD CONCEPTS	Lundholm, R.	Assoc AIEE Member Gothenburg, Sweden	May 2, 1957
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AIEE DP 57-568	A HYPOTHESIS CONCERNING LIGHTNING PHENOMENA AND TRANSMISSION LINE FLASHOVER	Johnson, IB Schultz, AJ	General Electric Pittsfield, MA	May 2, 1957
Discussion of Paper:	CALCULATION OF TRANSMISSION LINE LIGHTNING VOLTAGES BY FIELD CONCEPTS	Lundholm, R Finn & Price	American GAs & Electric - NY	Oct. 3, 1957
AIEE 57-1079	FACTORS AFFECTING THE LIGHTNING PERFORMANCE OF TRANSMISSION LINES	Hagenguth, JH Anderson, JG	General Electric Pittsfield, MA	May 31, 1957
Handwritten Notes	THEORY OF CLOUD CHARGE	??		1958
AIEE 58-24	THE LIGHTNING STROKE	Wagner, CF Hileman, AR	Westinghouse E Pittsburgh, PA	Oct. 14, 1957
AIEE 58-176	ARC DROP DURING TRANSITION FROM SPARK DISCHARGE TO ARC	Wagner, CF Lane, CM Lear, CM	Westinghouse E Pittsburgh, PA	Oct. 10, 1957
AIEE CP 58-189	ANOMALOUS FLASHOVERS ON TRANSMISSION LINES -- Part II	Miller, CJ Jr	Ohio Brass Co. Barberton, OH	Nov. 6, 1957

Number	Title	Author	Company	Date
AIEE 58-829	THE PRESTRIKE THEORY AND OTHER EFFECTS IN THE LIGHTNING STROKE	Griscom, SB	Westinghouse E. Pittsburgh, PA	March 10, 1958
Paper	THE TEINOGRAPH - A NEW HIGH-VOLTAGE SURGE RECORDER	Anderson, JG Giacomoni, RU	General Electric Pittsfield, MA	May 19, 1959
AIEE CP-59-275	RESPONSE OF A 345 kV TRANMISSION TOWER TO A SIMULATED LIGHTNING STROKE	Armstrong, HR BArthold, LO Schultz, AJ	Detroit Edison Co General Electric Schenectadcy, NY	1959
AIEE 59-341	DETERMINATION OF LIGHTNING RESPONSE OF TRANSMISSION LINES BY MEANS OF GEOMETRICAL MODELS	Fisher, FA Anderson, JG Hagenguth, JH	AIEE Members	Jan 21, 1959
AIEE 59-644	A NEW APPROACH TO THE CALCULATION OF THE LIGHTNING PERFORMANCE OF TRANSMISSION LINES - II	Wagner, CF Hileman, AR	Westinghouse E. Pittsburgh, Pa	Feb. 19, 1959
AIEE 60-657	DETERMINATION OF THE WAVE FRONT OF LIGHTNING STROKE CURRENTS FROM FIELD MEASUREMENTS	Wagner, CF	Westingbouse E. Pittsburgh, PA	Feb. 1, 1960
AIEE 60-658	A NEW APPROACH TO THE CALCUALTION OF THE LIGHTNING PERFORMANCE OF TRANSMISSION LINES PART III. A SIMPLIFIED METHODS - STROKE TO TOWER	Wagner, CF Hileman, AR	Westinghouse E. Pittsburgh, PA	Jan. 6, 1960
AIEE 61-88 CP	MONTE CARLO COMPUTER CALCULATION OF TRANMISSION LINE LIGHTNING PERFORMANCE	Anderson, JG	General Electric Pittsfield, MA	Oct. 26, 1960
AIEE 62-1094	RELATION BETWEEN STROKE CURRENT AND VELOCITY OF THE RETURN STROKE	Wagner, CF	Westinghouse E Pittsburgh, PA	March 21, 1962
AIEE CP 62-1181	EFFECT OF PREDISCHARGE CURRENTS UPON LINE PERFORMANCE	Wagner, C. F. Hileman, AR	WEstinghouse E. Pittsburgh, PA	April 11, 1962

Lightning - Theory

GED-483

GENERAL ELECTRIC REVIEW

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Effects of Short Lengths of Cable on Traveling Waves

By

K. B. McEachron, J. G. Hemstreet and H. P. Seelye

REPRINT

From November, 1930, Issue

Theory

A HYPOTHESIS CONCERNING LIGHTNING PHENOMENA AND TRANSMISSION LINE FLASHOVER

I. B. Johnson A. J. Schultz

INTRODUCTION

Unpredicted lightning outage rates on high voltage transmission lines have occurred over the years. More recently this fact has been emphasized by operating experience with new twin circuit high voltage transmission lines using one ground wire. Present methods of predicting lightning performance fall short of the experience records. The inadequacies of the current methods of prediction result in a lack of confidence of a certain degree in the evaluation of various designs of transmission lines and tower structures.

One method of calculating line performance is presented in an A.I.E.E. Committee Report.[1] Broadly the method of calculation from a circuit viewpoint is based on three areas of consideration:

1. Insulation strength of the insulator string.
2. Characteristics of lightning surges to transmission lines – magnitude, rate-of-rise and duration of surge current.
3. Surge response of the transmission line to lightning strokes – footing resistance, tower inductance, coupling factor, effect of ground wires, etc.

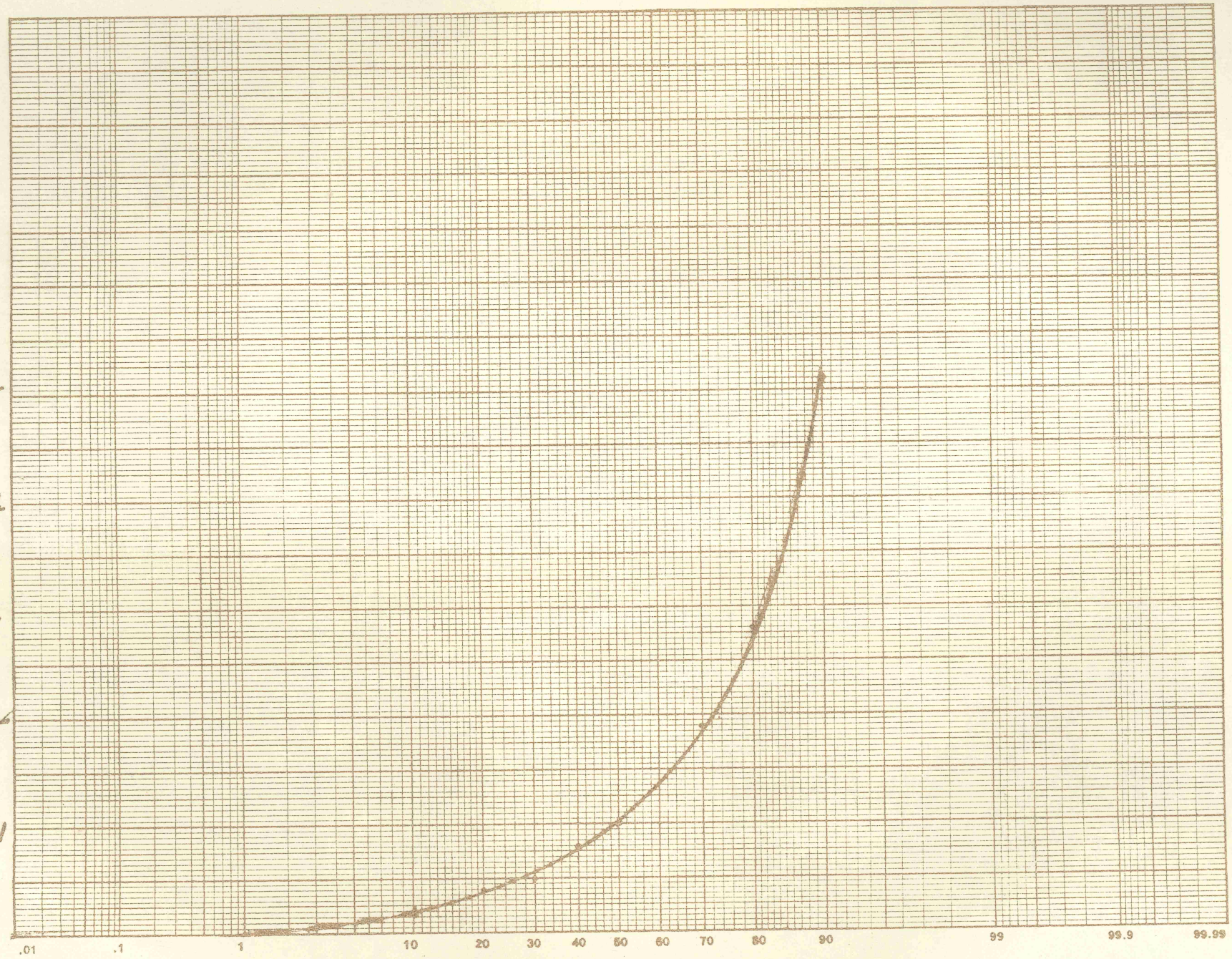
A critical review of the foregoing should reveal whether or not all of the factors have been realistically evaluated. If so, the A.I.E.E. method, perhaps, need only be modified to extend its validity and usefulness.

A current study is in progress to investigate the areas of insulation strength, surge response of the transmission line, and the severity of the lightning surges likely to be experienced on transmission lines. The results of the studies on insulation strength and surge response of transmission lines and towers are reported in companion papers.[2-6] The results of these studies have not produced sufficient modifying effects in the calculations to account for the unexplainable outage rates.

On the questions concerning the characteristics of lightning, there is some speculation pertaining to the magnitude and wave shapes of lightning surges occurring on transmission lines. Specifically, there are questions on the direct applicability of the data obtained on relatively tall structures, such as buildings and radio towers, to transmission lines and on the differences among the data obtained on various tall structures. It is the purpose of this paper to review these data from tall structures and to present a possible correlation of these data to the end that they may be more suitably applied to transmission line structures, resulting in a more accurate prediction of the lightning performance of high voltage transmission lines.

DATA ON MAGNITUDES OF STROKE CURRENTS

The methods of predicting line outages from lightning mentioned in the Introduction necessarily depend on a statistical knowledge of the severity of lightning strokes. This is generally expressed as a percentage distribution curve of the crest magnitudes of the currents measured in lightning strokes. A number of these percentage-distribution curves as obtained by different observers in different locations is shown in Figure 1. Curve A of Figure 1 was obtained from 30 magnetic link measurements of strokes to lightning rods mounted on top of towers and from 80 stroke measurements on overhead ground wires.[7]



PER CENT OF STROKE CURRENT HAVING TIMES TO WAVE FRONT CREST EQUAL TO OR LESS THAN ORDINATE

FIG 10

ANALYTICAL STUDIES ON LIGHTNING PHENOMENA INVOLVING TOWERS, INSULATOR STRINGS, AND TRANSMISSION LINES

I. B. Johnson
Member AIEE

A. J. Schultz
Member AIEE

INTRODUCTION:

Certain high voltage transmission lines have experienced line flashovers from lightning at a rate in excess of that anticipated for these lines by conventional methods of calculation.[1] Particularly has this been true for double-circuit lines using one ground wire.[2,3] Since these lines have very low footing resistances, it has been necessary to examine other factors which may be of significance and which heretofore have not been realistically appraised. One of these factors is the surge response of the tower and the nature of the lightning current required in the tower impedance to produce sufficient voltage to cause flashover.[4,5,6,7]

To assist in analyzing the foregoing factors, a series of tests were made using models of a transmission tower and its associated conductors. The design of the model tower was based on calculations and their verification by field studies on the surge characteristics of transmission towers.[3,7] This paper describes the design and construction of the model, the nature of the data obtained and the results that followed from these studies.

MODEL TOWER

The model tower is a miniature representation of an actual tower having a height of 170 feet. The miniature tower was arbitrarily assigned a height of 6 feet. This establishes a physical ratio of 170:6 or 28:1 between the actual system and the model. All physical dimensions of the tower and its associated conductors and ground wires must be represented in the model, therefore, by dimensions that are one-twenty-eighth of the same dimensions in the actual system.

The fundamental electrical constants which determine the surge response of any conductor are inductance and capacitance. Since:

$$\text{Inductance per unit length, } L \approx \ln \frac{2h}{r}$$

$$\text{Capacitance per unit length, } C \approx \frac{1}{\ln \frac{2h}{r}}$$

it can be seen that the inductance and capacitance for one foot of the model system will be equal to that of one foot of the actual system if the height and radius are reduced by the same ratio. Since the inductance and capacitance per unit length of the model system are identical with the inductance and capacitance per unit length of the actual system, the velocity of surge propagation is the same for the model as for the actual system. But since the distances involved in the model system are only one-twenty-eighth as long as the corresponding distances in the actual system, the times of travel on the model are one-twenty-eighth of those on the actual system. The round trip travel time of a surge on the actual tower, at the speed of light, is on the order of a third of a microsecond. The corresponding time on the model system would be, therefore, on the order of 10 millimicroseconds. With such a short time scale, the production of a surge with a sufficiently high rate of rise and the measurement of the phenomenon occurring on the model system becomes extremely difficult. This difficulty can be overcome by making a time base change.

AIEE
Miscellaneous Paper
50-163

May 1950
Litho in USA

PE KINGSBURY

A METHOD OF ESTIMATING LIGHTNING PERFORMANCE OF TRANSMISSION LINES

AIEE Working Group on Methods of
Estimating the Lightning Performance
of High Voltage Transmission Lines
of the
AIEE Lightning and Insulator Subcommittee

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A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer and Pacific General Meeting, Pasadena, Calif., June 12-16, 1950. Manuscript submitted May 15, 1950; made available for printing May 15, 1950.

Personnel of the AIEE Working Group on Methods of Estimating the Lightning Performance of High Voltage Transmission Lines: E.R.Whitehead, Chairman; L.V.Bewley, G.D.McCann, Jr., E.L.Harder, S.K.Waldorf, W.W.Lewis.

PRICE: 30¢ To Members
60¢ To Nonmembers

Lightning Theory

AMERICAN GAS AND ELECTRIC FLASHOVER PROBLEM

Minutes of Meeting – August 18, 1955 – Schenectady, New York

Present: G. D. Breuer, General Electric Company, Schenectady
C. Concordia, General Electric Company, Schenectady
C. M. Foust, General Electric Company, Schenectady
J. H. Hagenguth, General Electric Company, Pittsfield
I. B. Johnson, General Electric Company, Schenectady
W. S. Price, American Gas and Electric Service Corporation
R. Schlomann, American Gas and Electric Service Corporation
A. J. Schultz, General Electric Company, Schenectady
C. A. Woodrow, General Electric Company, Schenectady

1. Field and Analyzer Studies

Demonstrations were made of models developed so far as possible aids in the solution of the problem being considered. Field flux plotting results of a transmission tower and of a vertical wire were discussed also insofar as the surge impedance characteristics of the tower might prove to be a predominantly important factor.

A description was given of the field studies made on and at tower 268 of the Muskingum-East Lima 330 kv transmission line near Columbus, Ohio. Oscillographic records were made of the surge response characteristics of tower 268 with and without the ground wire connected, and of the effect of adjacent towers. Similarly results were obtained for an artificial tower and for a vertical wire both erected 200 ft. away from tower 268. In addition some capacitance measurements were made of the artificial tower and of the vertical wire. A memorandum giving the essence of the results of the field study is attached. To those present at the meeting it is to be mentioned that the memorandum modifies the data given at the time of the meeting.

2. Voltage-Time Flashover Recorder

Mr. Foust described refinements in the design of the recorder. Following discussions on the voltages that would actuate the recorder in relation to the voltages that would be acting on the insulator string to cause flashover, it was agreed that it would be desirable to calibrate the recorder both with a structural assembly and with surge currents simulating actual conditions as close as possible. It was agreed that the recorder be constructed with four R-C elements to record and cover anticipated surge voltage fronts ranging from 0.1 microsecond to 5 microseconds.

Mr. Foust agreed to:

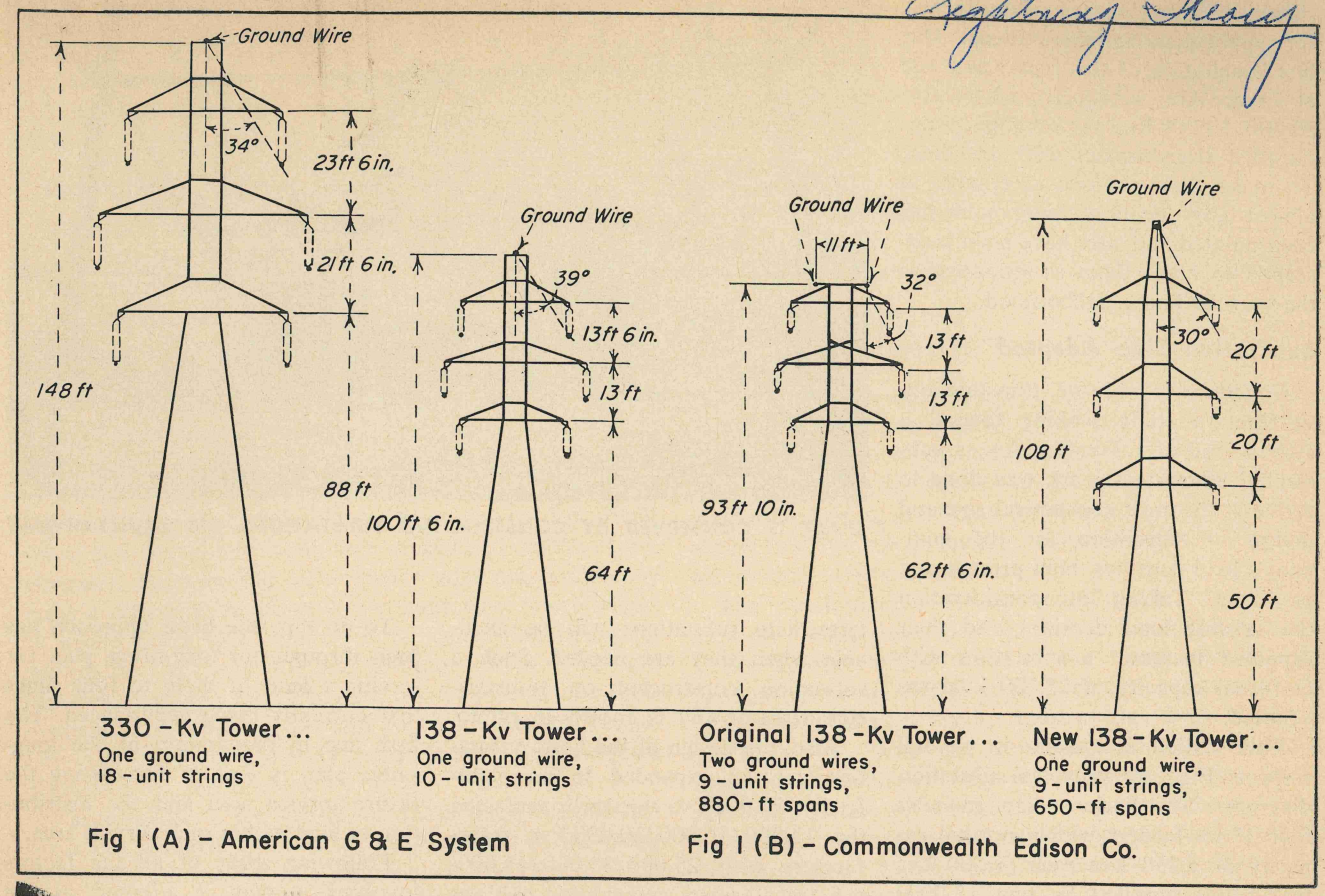
(a) Complete design of the Double Polarity Recorder.

(b) Manufacture a production sample for tests.

(c) Get cost extimates on manufacture of 400 recorders for 80 stations.

(d) Make laboratory calibrations of four element recorder without voltage divider.

Lightning Theory



Evaluation of New Tower Designs May Reveal . . .

Why EHV Lines Show Excess Outages

TRANSMISSION
Design

Lightning causes flashovers considerably in excess of the rate predicted from design data. Investigation reveals:

- **Burns on both upper and lower surfaces of suspension insulators removed from lines after flashover.**
- **Steep-front pulses in laboratory create similar markings.**
- **Test waves flash insulator strings shunted by tower leg.**

DR CHARLES J. MILLER, JR, Research Engineer, The Ohio Brass Co, Barberton, Ohio

Two power companies have experienced outages caused by lightning on extra-high-voltage tower lines far in excess of the rate predicted by usual methods. Studies seeking a satisfactory explanation are now underway.

Many of the outages resulted from flashovers of the top or the middle-phase insulator strings on towers with very low footing resistance. Examination of these insulators reveals glaze burns produced by lightning which indicate that the flashover paths hug both the upper and lower surfaces of each unit in the string. This characteristic suggests that the lightning voltage pulses which produce these glaze burns have very steep fronts.

Furthermore, glaze burns from the resulting power arc are generally found on both upper and lower surfaces of nearly every unit in the string. In a number of cases investigated, marks on the tower tops indicate where they were hit by lightning strokes.

Laboratory investigations show that when a steep front voltage pulse from a 3-million-v impulse generator is applied to a 22.5-ft section of 6-in. angle-iron tower leg, enough potential is produced to flash over a 3-unit string of suspension insulators connected in parallel with it. Glaze burns from these tests are very similar to those produced by natural lightning.

Photographic studies of flashovers produced in the laboratory with very steep front voltage pulses on various length insulator strings indicate strings could flash over in a fraction of a microsecond when subjected to suitably steep voltage pulses.

By use of traveling wave theory, it can be shown that when a lightning stroke hits the top of a tower, voltage at that point rises rapidly until reflected waves of opposite polarity return from the tower base and alleviate the

RB Finn, A.G.and E
W Price, A.G.and E
R Schlomann, A.G.and E

cc: VL Cox, 10-7
C Dorsa, New York Ofc.
GD Breuer, Schdy. Works
CM Foust, Schdy. Works
J Hagenguth, Pittsfield
BE Kingsbury, Baltimore
AJ Schultz, Schdy. Works
NR Schultz, Schdy. Works
CH Titus, 10-7
WR Wilson, 6-3
FC Vose, Baltimore
HA Frey, Baltimore

LABORATORIES DEPARTMENT - PHILADELPHIA
November 26, 1956

Mr. I. B. Johnson
Analytical Engineering
Bldg. 2-627
SCHENECTADY WORKS

I have reviewed with some care the paper "Principles for the Calculation of the Lightning Performance of a Transmission Line for a Direct Lightning Stroke to the Line" by Ragnar Lundholm, copies of which you sent to several engineers on May 31 of this year, and would like to summarize and comment on it as follows.

The paper describes a method for calculation of the voltage appearing across an insulator string on a conventional steel transmission line tower as a function of the lightning stroke current magnitude and steepness of front. It also includes calculations for several cases in which the lightning stroke current was 50,000 amperes, the front time varying from 0 to 1 microsecond. These calculations are referred to a typical American Gas and Electric 330kv transmission tower.

The method of calculations assumes that the stroke starts at the tower top and comprises the following steps:

1. Determination of the division of stroke current between tower and ground wire.

2. Establishment of a loop path including the insulator string for determination of induced voltage.

3. Determination of the voltage across each element of the new path induced by stroke current, tower current, ground wire current, and their ground reflections. In this determination, it was recognized that immediately after the inception of current, current would flow in only a small length of each conducting path immediately adjacent to the point of inception of the stroke, this length increasing as the wave travelled away from point of inception along the various paths.

Lightning - Theory - Calc.

PRINCIPLES FOR THE CALCULATION OF THE LIGHTNING PERFORMANCE OF A TRANSMISSION LINE FOR A DIRECT LIGHTNING STROKE TO THE LINE

BY: RAGNAR LUNDHOLM

Introduction

In the older theories for the computation of the lightning performance of a given type of line construction (the theory of Torok and Ellis-1933, of Jordan-1934, and of the author-1944) one is concerned chiefly with the voltage at the tower top or with the potential difference between the tower top and the phase conductors. In the calculations the tower is regarded either as a concentrated inductance or as a surge impedance. Some years ago the author began to suspect that these theories, including his own, are in some respects insufficient and he published in a CIGRE Report, #305, 1952, a very brief outline of a new theory. This new method has since been developed further and will be described below after the reasons for rejecting the older methods have been presented.

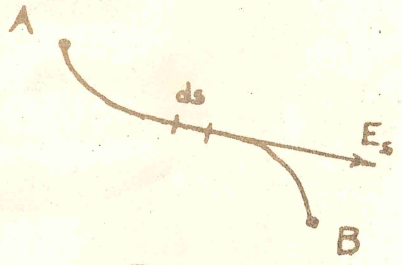


Fig. 0-1

The physical definition of the electric potential difference V between two points A and B is:

$$V_A - V_B = -\int_A^B E_S \, ds$$

Where E_S is the electric field component along the path of integration. In a pure electrostatic field V is independent of the path of integration and

4. Summation of all the voltages determined under (3) to give the total voltage generated around the loop. Since the loop was selected in such a way that no voltage could exist along any element of it except the insulator string, all of this voltage would appear across the insulator string.

There is one point with regard to the final step which is not made clear in the report and that is the question whether the summation is made all at the same time or whether some allowance is made for the time required for voltage generated in a relatively remote part of the loop to appear across the insulator string. Consider, for example, the voltage produced across the bottom ten feet of the tower as it is traversed by the surge of current flowing down the tower. If the voltages around the loop are summed just as the surge reaches the ground, this voltage will be included in the sum; yet it is difficult to see how this voltage could affect the voltage across the insulator string before a time enough later to allow its influence to reach there when traveling at the speed of light - approximately one tower transit time later. On this basis, summation on a simultaneous basis appears to be wrong but it is not clear from anything I have yet been able to find in the report that any other procedure has been followed. In fact, the statement on page 64 to the effect that "image currents will affect the voltage across the string before the string becomes enveloped in the sphere of influence from the image tower top" appears to indicate that simultaneous summation has been used. No very careful study has been made of the effect of any correction which might be required on this account, but it would appear that the voltage in the second tenth of a microsecond would be decreased and that in the third tenth possibly increased, resulting in more nearly a straight line or concave wave shape instead of the convex curve arrived at by the author.

There are three other items which may influence the result in some degree. These are:

1. The surge impedance of the stroke path is assumed to be so high that the stroke current is negligibly modified by any voltages appearing at the tower top.

2. The ground at the base of the tower is assumed to be infinitely conducting.

3. The author states that no attempt has been made to include the voltages generated by displacement currents.

From F. Hirschfeld
9/24/58

CHALMERS TEKNISKA HÖGSKOLAS
HANDLINGAR

TRANSACTIONS OF CHALMERS UNIVERSITY OF TECHNOLOGY
GOTHENBURG, SWEDEN

Nr 188 (Avd. Elektroteknik 58) 1957

Lightning - Theory

INDUCED OVERVOLTAGE-SURGES ON TRANSMISSION LINES AND THEIR BEARING ON THE LIGHTNING PERFORMANCE AT MEDIUM VOLTAGE NETWORKS

BY

R. LUNDHOLM

GUMPERTS FÖRLAG
GÖTEBORG

Lightning Theory

THE BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

LIGHTNING FLASH COUNTER.

The frequency of occurrence of lightning flashes to earth constitutes one of the main features of the lightning discharge on which more factual information is required by electrical supply engineers, physicists and meteorologists. An instrument capable of providing the necessary information must not only be technically sound but must also be simple and inexpensive so as to facilitate its world-wide distribution.

Following a suggestion by Dr E.T.Pierce of the Cavendish Laboratory, Cambridge, England, a lightning flash counter has been designed capable of recording lightning flashes to earth within a radius of about 40 kilometres (25 miles). The device, as illustrated, is operated by the electrostatic field change produced by the return stroke of a lightning flash to earth from a negatively charged cloud. It consists essentially of a cold-cathode valve connected to an input circuit designed to avoid operation as the result of slow field changes and of cloud discharges. An electromagnetic counter registers the operation of the device.

The instrument is fitted with two dry batteries of standard pattern and is thus independent of external electricity supply. A test button permits checking the operation. The counter is to be connected to an outside aerial, the dimensions of which will be specified in an instruction sheet to be issued with the instrument.

The counter is designated for use in the tropics. It is housed in a sheet steel case measuring 10 x 6 x 7 inches (25 x 15 x 17.5 cm). The total weight is $14\frac{1}{4}$ lb ($6\frac{1}{2}$ kg). The cost of the device is £23 with a possible slight reduction for bulk orders. Orders for the instrument should be addressed to -

Messrs A.E.Cawkell,
Electronic Engineers,
6-7 Victory Arcade,
Southall,
Middlesex, England.

April, 1957.

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MAR 20 1957
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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR	SUBJECT CLASSIFICATION	NO.
J.G.Anderson	1. Lightning. Theory 2. ~~Transmission~~ Lines. 3. Transient Phenomena.	57TP150
		DATE 1-2-57

TITLE Theory and Model Tests of Lightning Voltages on Transmission Lines.

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FEB 21 1957
H. A. FREY

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR	SUBJECT CLASSIFICATION	NO.
J.G.Anderson	1. Lightning. Theory 2. ~~Transmission Lines.~~ 3. Transient Phenomena.	57TP150
		DATE 1-2-57

TITLE Theory and Model Tests of Lightning Voltages on Transmission Lines.

ABSTRACT A study of the structure of the lightning stroke and its equivalent electric circuit is given. The magnitudes of the stroke capacitances to earth and to transmission lines are measured experimentally, and from these values stroke charges are computed. The nature of the surge current components produced by a direct stroke to a ground wire of a 330 KV double circuit system is then deduced.

G.E. CLASS	REPRODUCIBLE COPY FILED	NO. PAGES
II	TECHNICAL DOCUMENTS	60
GOV. CLASS NONE		

CONCLUSION

1. If an upward corona streamer 10 feet or more in length exists from a ground wire, the conventional concepts of mid-span lightning stroke voltages and currents are not seriously altered by the effects of released charges on the wires near the stricken point.
2. Measured capacitances to earth of a model lightning pilot streamer channel account roughly for observed currents and tail wave shapes of lightning currents, but certain axial voltage gradients and expansion of streamer diameters are required.
3. Magnetically induced currents for mid-span strokes can be neglected.
4. Various model system charge density measurements on lines, towers, and earth are included, as well as a theoretical area effect in transmission line protection.

By cutting out this rectangle and folding on the center line, the above information can be fitted into a standard card file.

For list of contents-drawings, photos, etc. and for distribution see reverse side.

INFORMATION PREPARED FOR General Information.

TESTS MADE BY D. C. Shampang, J. G. Anderson Tests Completed: Nov. 1, 1956

COUNTERSIGNED J. H. Hagenguth SECTION Power Transformer Engineering-High Voltage Research

BUILDING and ROOM No. 9-102 LOCATION Pittsfield Works

From Mr. Kingsbury
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H. A. FREY

Conductors

rrors Introduced Cables

John H. Park

THE
NATIONAL BUREAU OF STANDARDS
U. S. DEPARTMENT OF COMMERCE
Washington 25, D. C.

e to be done for each different wave-
e of applied surge. Also, it is not
pletely reliable unless the variation
ase shift with frequency is also taken
account.
n experimental approach is much
r to apply and probably more
reliable. One method is to arrange the surge generating circuit so that the pulse to be measured, or one similar to it in shape and rate of rise, can be accurately repeated from shot to shot. (The peak value can be repeated by using a linearly rising voltage chopped with a sphere gap.) Oscillograph records are then taken with (1) a measuring cable of minimum length L, (2) a cable twice this length $2L$, and (3) a cable three times this length $3L$. If the oscillograms obtained under these three conditions are appreciably different in waveshape or peak value, a cable having lower attenuation should be used or a correction for attenuation computed. Polyethylene coaxial cables are used to obtain low attenuation and attenuation can be reduced by using a cable of minimum length and one whose center conductor is large.

For surges which, in general, rise linearly and are chopped by the sparkover of a gap, a correction for the error in peak-voltage measurement due to cable attenuation can be determined. This is done by obtaining values of peak voltage with the three different cable lengths, L, $2L$, and $3L$ as indicated. The decrease in peak voltage ΔV when the cable length is changed from L to $2L$ should be the same as that obtained when the cable length is changed from $2L$ to $3L$, within the accuracy of the measurements. The average of the two values of ΔV is added to the peak voltage obtained with a cable of length L to correct for attenuation.

This method of correcting for cable attenuation was used during an investigation of the change in sparkover value of standard 12.5-cm (centimeter)-diameter spheres set 6 cm apart as the rate of rise of the applied voltage was increased. Values of ΔV were obtained for rates of voltage rise from 10 to 10,000 kv per μsec (microsecond). They were computed as a percentage of total voltage and plotted against rise time (time to sparkover) as obtained by dividing peak voltage by rate of rise. Results are shown in Fig. 1 for *RG-58/U* and *RG-8/U* coaxial cables.

Errors Due to Cable Termination

For most impulse and surge work the CRO cable is terminated by a noninductive resistor which is considered to be equal to its surge impedance in ohms and thus to produce no errors due to reflections. This assumption is not strictly justified, because the surge impedance of all cables varies with frequency and reflections due to different types of surges cannot all be prevented by a terminating resistor of fixed value. The change in impedance with frequency is introduced by (1) the cable resistance and conductance which put a $j\omega$ term in the impedance and can only be neglected over certain frequency ranges and (2) the change in cable inductance caused by nonuniform distribution of current in the sheath and center conductor as frequency is increased. This last factor is actually due to skin effect which also causes a change in resistance with frequency and further complicates factor 1.

Thurston[3] gives a plot in arbitrary units showing the variation of characteristic impedance with frequency for nominal 50-ohm polyethylene cables. Below 100 kc the impedance is given as constant and equal to 55 ohms. From 100 kc to 10 megacycles there is a gradual change from 55 to 50 ohms and it remains at 50 ohms for higher frequencies. Thus if a 50-ohm terminating resistor is used with such a cable (as would normally be

measurement error can readily be set up. However, all cables have some attenuation and their surge impedance is never the same for all frequencies.[1,2,3] In low-voltage impulse work (where very short cables can be used) such factors may be negligible under certain conditions, but for measuring high-voltage surges a fairly long cable (50 feet or longer) is usually required and possible errors caused by the cable should be considered, especially for measuring steeply rising surges. The purpose of this paper is to discuss such errors and devise methods for measuring and minimizing them.

Attenuation Errors

Cable losses are caused by the resistance of the center conductor and outside sheath together with conductance and dielectric hysteresis in the insulating material between conductors. Losses are usually expressed as an attenuation in decibels per 100 feet at a fixed frequency and in general the logarithm of attenuation in decibels increases in direct proportion to the logarithm of the frequency. For any given surge it is theoretically possible to determine the change in peak value and waveform caused by cable attenuation by using the known values of attenuation at various frequencies and the Fourier integral procedure. However such a procedure is time consuming and would

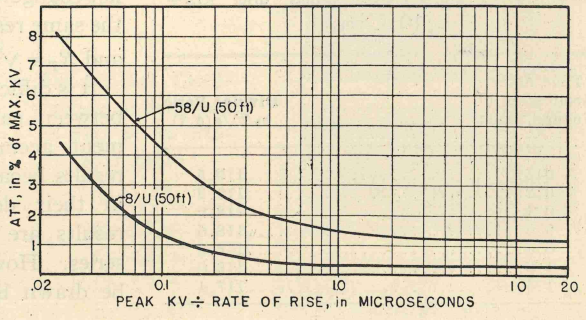

Fig. 1. Attenuation of linearly rising chopped surges by RG-58/U and RG-8/U coaxial cables

Paper 58-110, recommended by the AIEE Special Instruments and Auxiliary Apparatus Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., February 2-7, 1958. Manuscript submitted October 9, 1957; made available for printing November 8, 1957.

J. H. Park is with the U. S. Department of Commerce, National Bureau of Standards, Washington, D. C.

The author acknowledges the assistance of H. N. Cones and J. L. Mills of the National Bureau of Standards who performed the experimental work reported in this paper.

January 19, 1959

Mr. J. A. Rawls, Chairman
Towers, Poles, and Conductors
Subcommittee, AIEE
Virginia Electric and Power Co.
Richmond 9, Virginia

Dear Mr. Rawls:

Attached herewith is a summary of the replies to the questionnaire on broken wire assumptions, which was issued in 1958 under the auspices of the Transmission and Distribution Committee of the AIEE.

A working group of the Towers, Poles, and Conductors Subcommittee developed the questionnaire, distributed it to 63 utilities or agencies operating lines of 60 kv or higher, and analyzed the replies. As is usual in instances where questionnaires are utilized to obtain information, the comments which the various transmission engineers supplied along with the answers to the questionnaires are particularly interesting and informative. However, comments do not lend themselves to inclusion in summaries, and they are being tabulated in a far bulkier supplemental report in order that they may not be lost to the engineer interested in details. It is suggested that some means be found to place this bulkier information in the hands of transmission engineers concerned with the details of transmission design when the comments have all been tabulated.

The attached report summarizes the answers received to the questionnaire in fairly concise form, and is probably suitable for transmitting to our parent Transmission and Distribution Committee. In the event your Subcommittee finds it acceptable in its present form, enough copies have been provided to enable you to furnish this summary to all the members of the committee.

Very truly yours,

E. L. KANOUSE

ELK:GB

Attachment

Transactions Paper

(Reviewed and Accepted for Publication)

BUNDLED CONDUCTOR VOLTAGE GRADIENT CALCULATIONS

J. Reichman
Associate Member AIEE
The Hydro-Electric Power Commission of Ontario
Toronto, Ont., Canada

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H. A. EREY

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., February 1-6, 1959. Manuscript submitted October 27, 1958; made available for printing December 2, 1958.

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Paper No.
59-82

Discussion in Duplicate Due February 20, 1959.

Transactions Paper

(Reviewed and Accepted for Publication)

RELATIONSHIP BETWEEN CORONA AND RADIO NOISE ON TRANSMISSION LINES

PART II. CONDUCTOR AND INSULATOR CORONA

T. W. Liao
Member AIEE

J. J. LaForest
Associate Member AIEE

Both of:
General Electric Company
Pittsfield, Mass.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., February 1-6, 1959. Manuscript submitted November 3, 1958; made available for printing December 3, 1958.

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Transactions Paper

(Reviewed and Accepted for Publication)

~~Weller~~
~~Walters~~
~~Kaminski~~
~~Tesoro~~
Kingsbury

RADIO INFLUENCE VOLTAGES CAUSED BY SURFACE IMPERFECTIONS

ON SINGLE AND BUNDLE CONDUCTORS

T. W. Liao
Member AIEE
General Electric Company
Philadelphia, Pa.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Middle Eastern District Meeting, Baltimore, Md., May 19-21, 1959. Manuscript submitted February 13, 1959; made available for printing April 6, 1959.

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Conference Paper

Mr. Heller
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" Vose
" Walters
" Stevens
" Horton
" Hillman
" Corsky
" Lesti
" Kingsbury

SHORT-TIME ANNEALING CHARACTERISTIC OF ELECTRICAL CONDUCTORS

PART I. METHODOLOGY

L. F. Roehmann
Member AIEE
Kaiser Aluminum & Chemical Corp.
Spokane, Wash.

A paper recommended by the AIEE Transmission and Distribution Committee for presentation at the AIEE Summer and Pacific General Meeting and Air Transportation Conference, Seattle, Wash., June 21-26, 1959. Manuscript submitted March 23, 1959; made available for printing April 29, 1959.

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Mr. Weller
" Kaminski
" Jurotko
" Hoe
" Hopkins
" Stevens
" Horton
" Williams
" Conkey
" Seattle
" Kingsbury

LABORATORY AND FIELD EVALUATION OF CONNECTORS AND OTHER ACCESSORIES FOR ALUMINUM CONDUCTORS IN SEVERE MARINE ENVIRONMENTS

William J. Sanders
Member AIEE
Kaiser Aluminum & Chemical Corp.
Spokane, Wash.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer and Pacific General Meeting and Air Transportation Conference, Seattle, Wash., June 21-26, 1959. Manuscript submitted March 23, 1959; made available for printing April 28, 1959.

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Paper No.
59-899

Discussion in Duplicate Due July 10, 1959.

Conductors

Transactions Paper

(Reviewed and Accepted for Publication)

ICE BUILD-UP ON CONDUCTORS OF DIFFERENT DIAMETER

E. K. Lanctot
Associate Member AIEE
Aluminum Co. of America
Massena, N. Y.

H. E. House
Member AIEE
Aluminum Co. of America
Massena, N. Y.

E. L. Peterson
Member AIEE
American Electric Power Service Corp.
New York, N. Y.

E. S. Zobel
Associate Member AIEE
American Electric Power Service Corp.
New York, N. Y.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11-16, 1959. Manuscript submitted June 8, 1959; made available for printing July 20, 1959.

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Paper No.

59-1122

Discussion in Duplicate Due October 30, 1959.

Transactions Paper

(Reviewed and Accepted for Publication)

ICE BUILD-UP ON CONDUCTORS OF DIFFERENT DIAMETER

E. K. Lanctot
Associate Member AIEE
Aluminum Co. of America
Massena, N. Y.

H. E. House
Member AIEE
Aluminum Co. of America
Massena, N. Y.

E. L. Peterson
Member AIEE
American Electric Power Service Corp.
New York, N. Y.

E. S. Zobel
Associate Member AIEE
American Electric Power Service Corp.
New York, N. Y.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11-16, 1959. Manuscript submitted June 8, 1959; made available for printing July 20, 1959.

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Paper No.
59-1122

Discussion in Duplicate Due October 30, 1959.

RESEARCH STUDY
ON
GALLOPING OF ELECTRIC POWER TRANSMISSION LINES

Progress Report

No. 1

December 1, 1959

AEROELASTIC AND STRUCTURES RESEARCH LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

RESEARCH STUDY
ON
GALLOPING OF ELECTRIC POWER TRANSMISSION LINES

PROGRESS REPORT

NO. 2

FEBRUARY 1, 1960

AEROELASTIC AND STRUCTURES RESEARCH LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

Conductors

Conference Paper

EMISSIVITY OF WEATHERED CONDUCTORS AFTER SERVICE IN RURAL AND INDUSTRIAL ENVIRONMENTS

W. S. Rigdon
Nonmember AIEE
Purdue University
Lafayette, Indiana

H. E. House
Member AIEE
Aluminum Company of America
Massena, N. Y.

R. J. Grosh
Nonmember AIEE
Purdue University
Lafayette, Indiana

W. B. Cottingham
Nonmember AIEE
Purdue University
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Paper No. CP
60-840

DISCUSSION OF CONFERENCE PAPER NO 60-1273

"EFFECT OF BUNDLED CONDUCTOR FIELD

INFLUENCE ON E. H. V. TRANSMISSION

LINE DESIGN"

BY

R. W. HARMON
THE OHIO BRASS COMPANY
BARBERTON, OHIO

DISCUSSION BY:

R. L. MC COY
AND
J. KAMINSKI
INSULATOR DEPARTMENT GENERAL ELECTRIC COMPANY
BALTIMORE, MARYLAND

OCTOBER 12, 1960

Conductors

Conference Paper

TEMPERATURE, CURRENT, AND RESISTANCE CHARACTERISTICS OF BARE ALUMINUM DISTRIBUTION CONDUCTORS

Earl Hazan
Member AIEE
Kaiser Aluminum & Chemical Co.
Spokane, Wash.

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H. A. FREY

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Paper No. CP
61-234

Conductor

District Conference Paper

FIRST REPORT ON FIELD INVESTIGATION OF THE EFFECTS OF CONDUCTOR AGING AND CLEANING ON ELECTRICAL CONNECTIONS

O. A. Boyer
Member AIEE
Central Power and Light Co.
Corpus Christi, Texas

J. Hus
Associate Member AIEE
Burndy Corp.
Norwalk, Conn.

A paper recommended by the AIEE Transmission and Distribution Committee for presentation at the AIEE South East-South Central District Meeting, New Orleans, La., April 5-7, 1961. Manuscript submitted February 2, 1961; made available for printing February 10, 1961.

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Paper No. DP
61-496

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Conductors

Conference Paper

THERMAL LIMITS OF OVERHEAD CONDUCTORS AT VARIOUS METEOROLOGICAL CONDITIONS

J. A. McElyea
Associate Member AIEE
Illinois Power Company
Decatur, Ill.

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E. A. FERRY

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Paper No. CP
61-823

Conductors

Conference Paper

THE ELECTRICAL PROPERTIES OF SINGLE-LAYER ALUMINUM CONDUCTORS, STEEL-REINFORCED (ACSR), HAVING SINGLE STEEL CORE WIRES WITH HEAVY ALUMINUM COATING

C. H. Jensen (Retired)
Associate Member AIEE
Copperweld Steel Co.
Glassport, Pa.

R. E. DeMuth
Associate Member AIEE
Battelle Memorial Institute
Columbus, Ohio

R. W. Mowery
Associate Member AIEE
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Paper No. CP
61-813

Conductors

Conference Paper

SAG AND TENSION CALCULATIONS BY THE NOMOGRAPHIC METHOD

Robert H. Sarikas
Member AIEE
Illinois Power Company
Decatur, Ill.

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Paper No. **CP 62-107**

Chart Finds Transmission Gradient Factor

KARL W. SCHMIDT, Winnipeg, Manitoba

Conductor surface gradient, which is dependent on at least seven independent parameters, can be found with this nomogram. It can be valuable for gaining first information for such considerations in EHV work as electrostatic unbalance, corona loss and radio interference.

The scales and curves of this chart have been derived from the generally known equation below for F_1, which is assumed to give the desired information with sufficient accuracy. This equation, and so the nomogram, is based on the assumption of balanced charges and symmetrical bundle spacings not smaller than five conductor diameters.

The following apply:

d = conductor diameter
H = line height
D = phase spacing
s = subconductor spacing
} cm in equations; British units in chart

n = number of subconductors
E = line-to-line operating voltage, kv
F_1 = gradient factor, v(rms) per cm per kv(rms)
F_2* = strand factor, dimensionless
G = maximum surface gradient, kv (rms) per cm

$$G = \frac{EF_1}{1{,}732}$$

$$F_2 = \frac{G \text{ for stranded conductor}}{G \text{ for smooth conductor of same diameter}}$$

$$F_1 = 2{,}000F_2\left(\frac{1}{d} + \frac{n-1}{s}\sin\frac{\pi}{n}\right)(n \log_\epsilon AB)^{-1}$$

where $A = 2^{n+1/n}(\alpha\, ds^{n-1})^{-1/n}$

$$\alpha = \begin{cases} 1. & \text{when } n = 1, 2 \text{ or } 3 \\ 1.405 & \text{when } n = 4 \\ 2.601 & \text{when } n = 5 \\ 6.192 & \text{when } n = 6 \end{cases}$$

$B = HD(4H^2 + D^2)^{-1/2}$ for center phase

$B = HD[(4H^2 + D^2)(H^2 + D^2)]^{-1/4}$ for each outer phase

The procedure for finding the maximum gradient is as follows:

• Single conductor. Enter the chart at the right with phase spacing, D, go across to height, H, then down to edge L_3. Draw a straight line from here to P_1.

Draw a perpendicular to this line from the grid point, strand factor, F_2, vs conductor diameter, d, (upper right grid) to scaleless line L_4.

Read the result where a straight line connecting this point with P_2 intersects the gradient factor scale. This gradient factor multiplied by line voltage and divided by 1,732 yields the maximum conductor surface gradient (first equation). The small sketch at the bottom of the opposite page shows the method.

• Bundled conductor. Proceed as above, but instead of P_1 and P_2, use the projections on L_1 and L_2 drawn from the grid points determined by the ratio $\frac{s}{d}$ and the number of subconductors, n. Again, a sketch shows the method.

Sometimes the literature assumes that corona loss is a function of either the average gradient factor or the arithmetic mean between average and maximum factors. If, then, instead of taking the projection on L_2 one enters the lower left grid with s (2 through 6) on line L_2, the result is not the maximum but the average value of the gradient factor.

Examples given in the table are based on curves by Adams[2] and Reichmann[3] computed by digital computer. These results check within 1½% of those obtained by the nomogram.

Phase	Adams Center	Reichmann Center	Reichmann Outer	Reichmann Outer	Hand-Calculated Center
d	1.5	1.0	1.1	0.6	1.246
D	20	35	25	35	30
H	60	40	40	35	60
n	1	2	3	4	4
s	.....	10	12	12	24.92
F_2	1.0	1.0	1.0	1.0	1.4
E	330	340	460	352	500
G	17.71	16.65	16.65	16.65	20.32
By Nomogram:					
F_1	90	83	61.4	80	69.5
G	17.15	16.29	16.31	16.26	20.06

The nomogram makes it possible to define and determine equivalent conductor diameters, not only in considering equality of corresponding gradients, but also with respect to any other quantity.

* Not to be mistaken for *stranding* factor as recently defined by L. N. Stone. According to G. E. Adams[3], the strand factor equals 1.4 "if the stranding does not change the capacitance appreciably." This assumption may not apply to bundled conductors. If not, F_2 could be determined by W. S. Peterson's formulas[1].

Design of 500-Kv California Intertie Disclosed

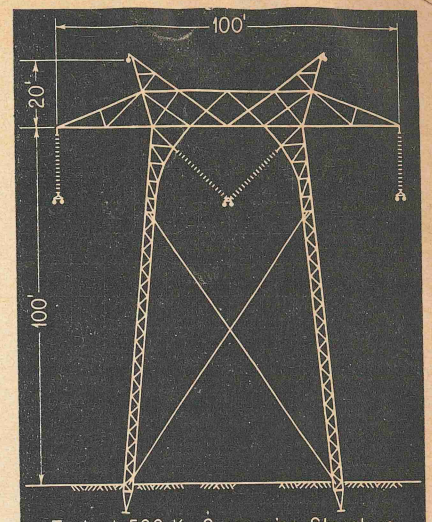
Details of the proposed 103-mile 500-kv line linking systems of the Pacific Power & Light Co and Pacific Gas & Electric Co have now been disclosed.

Some 600 latticed-steel guyed H-frame structures 100 ft wide and 120 ft high will be used in the $11-million line which will extend from Klamath Falls, Ore., to Round Mountain near Redding, Calif. (EW, Jan. 29, p 55). The average span is 900 ft. Each phase will consist of two ACSR Chuckar conductors of 1,780-MCM aluminum, 1.6 in. dia, spaced 18 in. horizontally. Outside phases use suspension strings of 35 insulators. Center phase conductors are restrained by two V-strings of 35 units, as shown.

The line will be designed and constructed for a maximum voltage of 550 kv. This is a 10% tolerance above the nominal 500 kv rather than the 5% currently used in the US. In addition the line design takes into consideration the fact that much of the route is over mountainous and rolling country at 5,000-ft elevation with the maximum at 5,800 ft.

The PG&E-designed structures, shown, will have longitudinal guys from the two 3-ft square legs to the ground. However, the structure is essentially stable without them, PG&E's W. R. Johnson told *Electrical World*. Steels to be used are ASTM A-7 medium strength and high elastic with ultimate strength not less than 65,000 psi and yield strength not less than 45,000 psi. Steel grillage footing will be used.

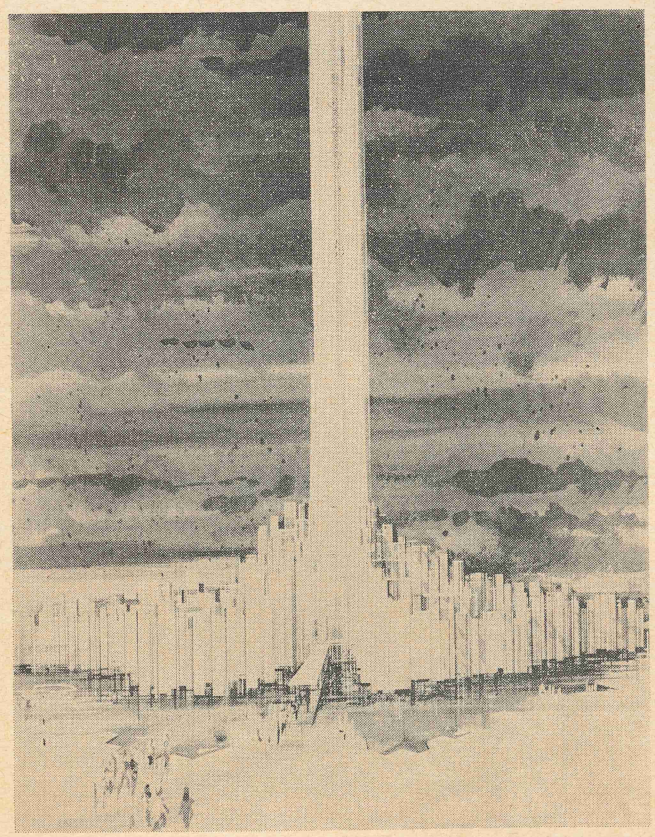
Design has been coordinated with PP&L for uniformity. Each company will build half the line. When completed in 1963 it will be the first line built for commercial use at this voltage in the US. It will operate initially at 230 kv with 230/500-kv substation faciliites added later, when justified.



Typical 500-Kv Suspension Structure

No design details have been furnished on the similar 500-kv intertie to Southern California Edison from PG&E's Round Mountain Substation (EW, April 2, p 26).

Industry to Present Exhibit at NY World's Fair



PAVILION FOR NEW YORK FAIR (above) was designed by Robinson-Stern, who designed the industry's Seattle exhibit

The nation's investor-owned electric utilities' exhibit at the 1964-65 New York World's Fair will be housed in a newly designed "pavilion of light prisms," according to Ernest R. Acker, chairman of the board of Central Hudson Gas & Electric Corp and president of the corporation set up to administer the utilities' participation in the fair.

"Vertically staggered triangular metal prisms will rise to a height of 80 ft, forming an asymmetrical structure resembling a crystal palace of ever-changing light and color or a sort of Gothic 'Cathedral of Light,'" Acker said.

Three Pylons Crown Exhibit

Crowning the pavilion will be three vertical pylons rising an additional 60 ft. The pylons will frame a vertical shaft of brilliant light and power rising from a central core on the ground level of the structure. This can be reviewed from a moving ramp carrying visitors across a reflecting pool to the pavilion entrance.

The interior walls of the vertical prisms are designed to serve directly as a background for the exhibit, becoming curtains of varicolored light. Visitors will be carried through the exhibit chambers on an elevated revolving ring and will exit by a spiral ramp, leading them past the core of the tower of light.

"With the prisms appearing to change color by day and the extending effect of the tower of light high above the fair at night, the new pavilion will present a dramatic picture," Acker commented.

Conductors

Conference Paper

FAULT AND LOAD CURRENT TESTING OF A BUNDLE CONDUCTOR SPACER

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Associate Member AIEE
American Elec. Pwr. Serv. Corp.
New York, N. Y.

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Centralia, Mo.

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A. B. Chance Co.
Centralia, Mo.

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Paper No. CP
62-284

Conductors

Conference Paper

RADIO NOISE AGING CHARACTERISTICS OF SMALL ALUMINUM CONDUCTORS

J. J. LaForest
Member AIEE

E. A. Whepley
Associate Member AIEE

Both of:
General Electric Company
Pittsfield, Mass.

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Paper No. **CP 62-251**

Transactions Paper

(Reviewed and Accepted for Publication)

EQUIGRADIENT LINES IN THE VICINITY OF BUNDLE CONDUCTORS

A. S. Timascheff
Member AIEE
Aluminum Company of Canada, Ltd.
Montreal, P. Q., Canada

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Paper No.
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Discussion in Duplicate Due October 26, 1962.

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EQUIGRADIENT LINES IN THE VICINITY OF BUNDLE CONDUCTORS

A. S. Timascheff
Member AIEE
Aluminum Company of Canada, Ltd.
Montreal, P. Q., Canada

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 7-12, 1962. Manuscript submitted June 6, 1962; made available for printing August 9, 1962.

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Discussion in Duplicate Due February 15, 1963.

I·E·E·E

ELECTRODYNAMIC STUDIES OF BUNDLED CONDUCTOR SPACERS

J. R. Ruhlman
Member IEEE

R. A. Eucker
Application Pending

R. L. Swart
Application Pending

All of:
Preformed Line Products Company
Cleveland, Ohio

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63-88

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Conference Paper

DESIGN CHARACTERISTICS OF THE 5005 ALL-ALUMINUM ALLOY CONDUCTOR FOR THE VEPCO 500 KV PROJECT

H. W. Adams
Senior Member IEEE
Reynolds Metals Co.
Richmond, Virginia

John Shaw
Senior Member IEEE
Virginia Electric & Power Co.
Richmond, Virginia

District Paper for presentation at IEEE Southeastern District Meeting in Richmond, Virginia, April 24, 25, and 26, 1963.

Paper No. CP
63-657

District Conference Paper

APPLICATION OF COMPUTER TO THERMAL RATING OF OVERHEAD CONDUCTORS

T. Hunter
Senior Member IEEE

K. E. Voigt

Both of:
Duquesne Light Co.
Pittsburgh, Pa.

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Paper No. DP
63-783

Conference Paper

ON THE DESIGN OF BUNDLE CONDUCTOR SPACERS

A. T. Edwards
J. M. Boyd

Both of:
The Hydro-Electric Power Commission of Ontario
Toronto, Ont., Canada

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Paper No. CP
63-1075

GENERAL ELECTRIC CO.

PROJECT EHV

American Electric Power Service Corp.

Conductor Characteristics for 1000/1100-Kv A-C Transmission

Report No. 2

L. O. Barthold
August 20, 1963

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Conference Paper

EVALUATION OF SPACERS FOR BUNDLED CONDUCTOR TRANSMISSION LINES

R. A. Krahn
Member IEEE

M. B. Bessler

Both of:
U. S. Department of the Interior
Bureau of Reclamation
Denver, Colorado.

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Paper No.
69 CP 8 - PWR

M Kingsbury

H. A Frey

A PROPOSED FRICTION DAMPER FOR GALLOPING CONDUCTOR WAVES

A. H. Kidder
Fellow IEEE
Philadelphia Electric Company
Philadelphia, Pa.

A paper recommended by the IEEE Transmission and Distribution Committee of the IEEE Power Group for presentation at the IEEE Summer Power Meeting, New Orleans, La., July 10-15, 1966. Manuscript submitted October 6, 1965; made available for printing March 22, 1966.

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Paper No.
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BPA TRANSMISSION LINE STRUCTURES

Wood and Steel Designs

A. A. Osipovich
Member A.I.E.E.

U. S. BONNEVILLE POWER ADMINISTRATION

January 1953

MODERN 220-KV STEEL TOWER TRANSMISSION LINE CONSTRUCTION

Eduard Fritz
Associate Member AIEE

A. N. Shealy
Member AIEE

Both of:
Pennsylvania Water & Power Co.
Baltimore, Maryland.

Prepared for Presentation

at the

Conference on Steel and Wood Towers

AIEE Winter General Meeting, New York, N. Y.

January 20, 1953

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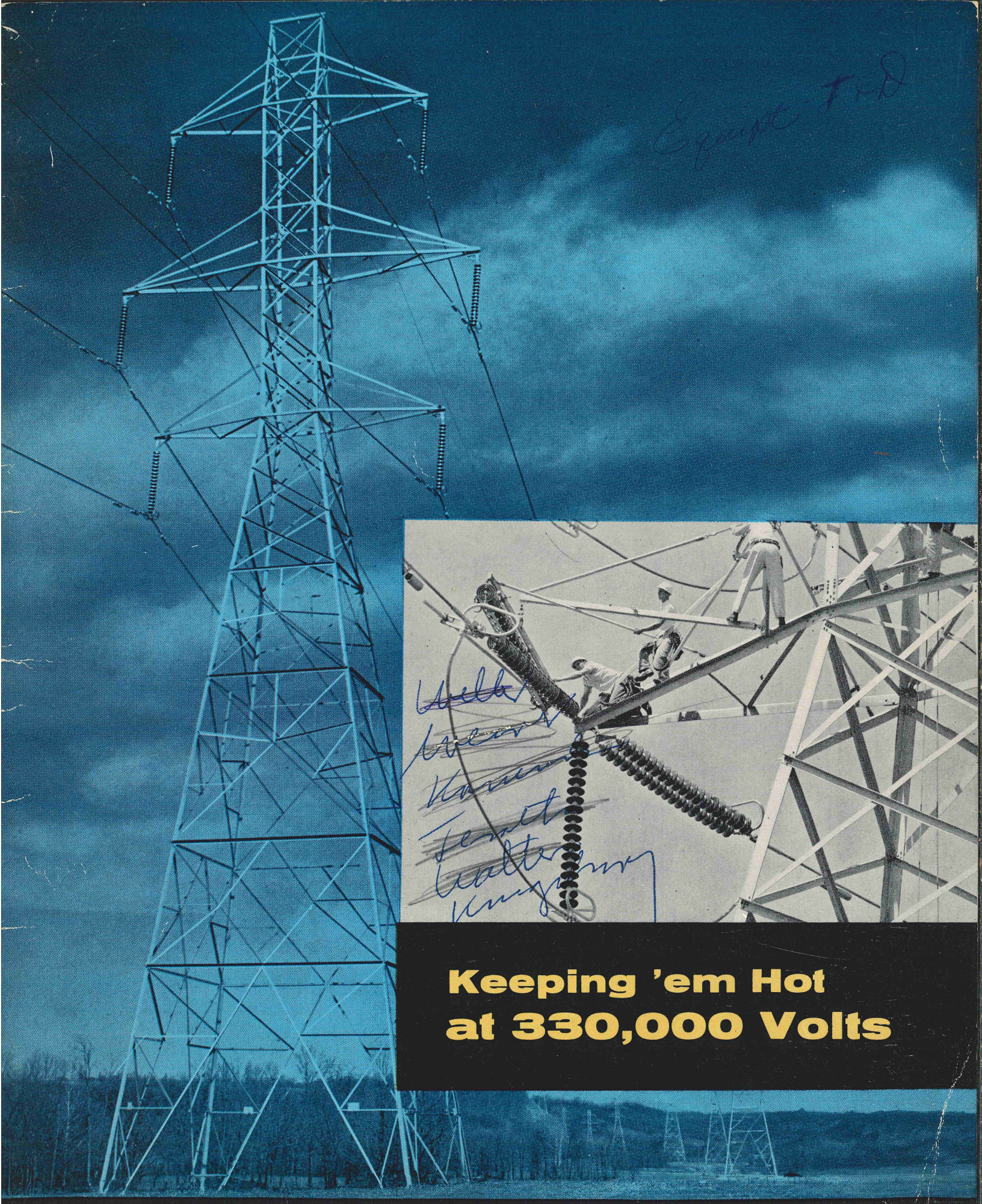

Keeping 'em Hot at 330,000 Volts

AMERICAN GAS AND ELECTRIC COMPANY SYSTEM

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Conference Paper

HIGH SPEED MAGNETIC AIR BREAKER FOR DISTRIBUTION CIRCUITS

H. P. Sleeper
Fellow AIEE
Public Service Electric & Gas Co.
Newark, N. J.

J. D. Findley
Associate Member AIEE
Westinghouse Electric Corp.
East Pittsburgh, Pa.

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Equip. - T&D

District Conference Paper

ADVANCES IN FEEDER PROTECTION THROUGH ELECTRONICS

R. F. Jones
Associate Member AIEE
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McGraw Edison Company
Birmingham, Ala.

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H. A. FREY

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Paper No. DP
62-518

Equip. - T&D

District Conference Paper

MAINTENANCE OF GALVANIZED STEEL TOWERS AND SUBSTATION STRUCTURES

T. J. Eberhardt
Subox, Inc.
Hackensack, N. J.

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H. A. FREY

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Paper No. DP
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Equip. - T&D

District Conference Paper

DIELECTRIC TESTING OF INSULATED AERIAL BASKETS

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R. L. Murray
Member AIEE

Both of:
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Birmingham, Ala.

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H. A. FREY

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Paper No. DP
62-529

DOCUMENT NO. 65SD364

TECHNICAL INFORMATION SERIES

TITLE

GENERALIZED FRAME ANALYSIS COMPUTER PROGRAM

AUTHOR

J. Gallagher

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FN-612 (12-68)

RE-ENTRY SYSTEMS DEPARTMENT

GENERAL ELECTRIC

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NOV 23 1966
M. JADVANI

Time to go on a statistical diet for

Structural reliability

Are your products overweight—yet unreliable as far as strength goes? If so, then you should design with statistical data in mind

C. DICKS, Structural Specialist, S. WILSON, Project Engineer, General Electric Co, Daytona Beach, Fla

MORE savings in weight and cost are possible by applying reliability techniques to structural design rather than to areas such as electronics. The problem, however, is that the structural designer, whether he is working on automobiles, missiles, aircraft, or home appliances, knows very little about statistical analysis—and the reliability expert knows very little about strength analysis.

The classic approach in structural design is to determine working design stresses by multiplying the actual stresses by a safety factor. Then the working design stresses are compared with the allowable strengths to obtain the margins of safety.

But when many structural components are involved and weight or material costs are important factors companies tend to take the final design, which includes the compounded safety factors, and arbitrarily reduce the final safety factor to obtain a more realistic design. They then build the assembly and subject it to dynamic testing, and when certain parts fail, as they sometimes do, they "beef up" portions of the design—a very costly and undesirable procedure.

The new approach, just beginning to take hold, is to determine the "probability of success" (the probability of failure is equal to one minus the probability of success, so adding the two factors together gives a value of unity). This probability-of-success-factor can then obsolete the safety factor in many complex designs.

The technique involves applying common statistical methods, such as the Monte Carlo method, to obtain a more realistic tie-in between loads, tolerances, and stresses. Because of the need for repetitive calculations, it is best to conduct the method on a computer, but a desk calculator may do in some cases.

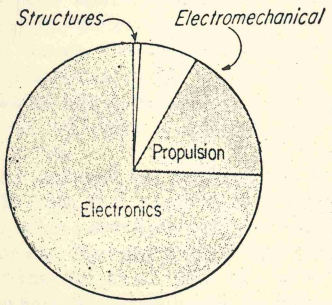
A simple problem is given here, with a step-by-step procedure based on the actual design of a structure—an automobile door handle.

Where do most failures occur?

Experience tells us that electronic systems are more likely to cause a failure—especially in missiles, Fig 1—than are structures. So it is natural that electronics should receive the greatest attention and program cost, Fig 2.

Thanks to this highly subsidized research, the electronics engineer can tell approximately what the failure rate will be for a particular electronic system. Not so the structural designer. Without such "standard failure rates," he usually just compares the design

1..FAILURES



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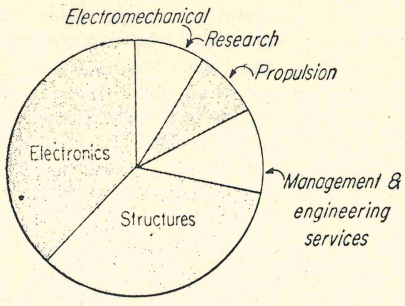
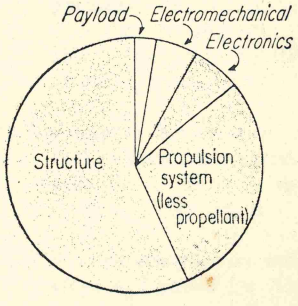


3..WEIGHT



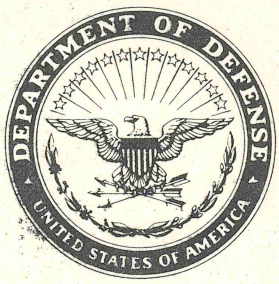
Typical missile failure sources. Most failures occur in the electronics area. Structural failures are almost nonexistent—but in many cases structures are overweight. **Missile program costs** are high for structures because of the bulk of expensive materials and processes, so the slight increase in design cost by going to a structural reliability program is easily absorbed by the resulting savings that is obtained in materials and in electronic design costs. **Largest weight contributor** in a missile system (when the propellant of the propulsion system is excluded) is structures.

MIL-STD-202C
12 September 1963

SUPERSEDING
MIL-STD-202B
14 March 1960

MILITARY STANDARD

TEST METHODS FOR ELECTRONIC AND ELECTRICAL COMPONENT PARTS



INDEX FOR: MATHEMATICAL CHARTS, CURVES, CALCULATIONS

Number	Title	Author	Company	Date
Reprint	POLAR TO RECTANGULAR CONVERSION CHART	Olmstead, Don G.	Vickers, Inc.	
Booklet	A GUIDE TO UTILIZATION OF THE BINOMIAL AND POISSON DISTRIBUTIONS IN INDUSTRIAL QUALITY CONTROL	Holbrook Working	Stanford Univ.	1947
AIEE 50-246	TRANSPOSITIONS AND THE CALCULATION OF INDUCTANCE FROM GEOMETRIC MEAN DISTANCES	Boast, WB	Iowa State College Ames, Iowa	August 1950
AIEE 51-226	DETERMINATION OF INSTANTANEOUS CURRENTS AND VOLTAGES BY MEANS OF ALPHA, BETA, AND ZERO COMPONENTS	Duesterhoeft, WC Schulz, Max W Jr Clarke, Edith	Univ. of Texas GE -Pittsfield Univ. of Texas	May 1951
Reprint Electric Light & Power	General Electric POWER-REACTIVE DIAGRAMS STILL USEFUL	Butler, RM	General Electric Schenectady, NY	July-Aug 1952
AIEE 53-182	A DIRECT METHOD FOR SAG-TENSION CALCULATIONS	Harley, TP	Bur of Reclamation Denver, Colorado	April 1953
AIEE 53-401	ELECTROSTATIC UNBALANCE TO GROUND OF TWIN CONDUCTOR LINES	Gross, Eric TB McNutt, WJ	Illinois Inst. of Technology, Chicago	August 1953
AIEE 54-213	EVALUATION OF THE INTEGRATION METHOD FOR ANALYSIS OF NON=STANDARD SURGE VOLTAGES	Jones, Andrew R	Westinghouse Pittsburgh, PA	April 1954
AIEE 55-477	ELECTROMAGNETIC UNBALANCE OF UNTRANSPOSED TRANSMISSION LINES, II. SINGLE LINES WITH HORIZONTAL CONDUCTOR ARRANGEMENT	Gross, ETB Nelson, SW	Illinois Inst. of Technology Chicago, IL	May 1955
AIEE 55-479	A RATIONAL METHOD FOR THE STEP-BY-STEP CALCULATIONS IN POWER SYSTEM TRANSIENT STABILITY STUDIES	Norinder, EO	Swedish State Power Bd - Stockholm, Sw	May 1955
57GL330	DIAKOPTICS - PIECWISE SOLUTION OF LARGE-SCALE SYSTEMS INTRODUCTION - AN INTRODUCTION TO UNIVERSAL ENGRG.	Kron, Gabrie	GE	October 1957
57GL330-1	DIAKOPTICS - PIECEWISE SOLUTION OF LARGE-SCALE SYSTEMS Chapter I - TOPOLOGY OF PIECEWISE ANALYSIS	Kron, Gabriel	GE	October 1957

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TRANSPORTATION SYSTEMS DIVISION

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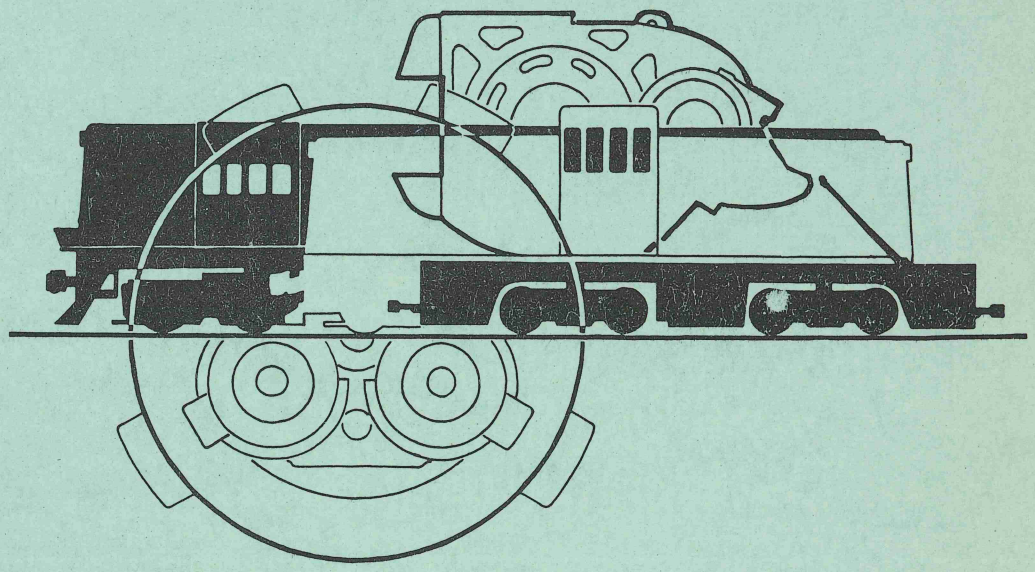
POWER COLLECTION AT HIGH SPEEDS BY NON-STEERING GROUND ORIENTED VEHICLES - REPORT ON VISIT TO ENGLAND -

R. T. Gray

G.E. Class - 1

DF67LC1955 7-28-67



RAILROAD ELECTRIFICATION:

A Technical Discussion on Pantographs, Catenaries and Locomotives

GENERAL ELECTRIC

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CLASS 2

RAILWAY OVERHEAD CONTACT SYSTEMS, CATENARY-PANTOGRAPH DYNAMICS FOR POWER COLLECTION AT HIGH SPEEDS

by

S. Levy, J. A. Bain, and E. J. Leclerc
Mechanical Technology Laboratory

Report No. 67-C-259

June 1967

GENERAL ELECTRIC

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SCHENECTADY, NEW YORK

TECHNICAL INFORMATION SERIES

AUTHOR	SUBJECT	NO.
Levy, S Bain, JA Leclerc, EJ	railway catenary-pantograph dynamics	67-C-259
		DATE: June 1967
TITLE: Railway Overhead Contact Systems, Catenary-Pantograph Dynamics for Power Collection at High Speeds		G.E. CLASS: 2
		GOVT. CLASS: None
ADDITIONAL COPIES AVAILABLE AT **Distribution Unit, Bldg. 5, Room 345** **Research and Development Center** **P.O. Box 8, Schenectady, New York 12301**		NO. PAGES: 64

SUMMARY

A program has been prepared for the GE-625 computer in FORTRAN IV language to compute the dynamic behavior of a catenary and pantograph for railroad cars moving at constant velocity. The catenary is considered to consist of two wires joined by elastic hangers* at arbitrary locations. The upper catenary wire is in turn supported by elastic towers at arbitrary locations. Account is taken of tension and mass in each wire, wire sag, damping of the wires, springing between shoe and wire, springing and damping between shoe and pantograph frame, damping of the pantograph frame to the railway car, lifting of the wire away from the shoe, and stops in the pantograph to limit motion between shoe and pantograph frame. Up to eight arbitrarily spaced pantographs can be included, with as many as sixty hangers and ten towers.

*droppers

KEY WORDS: railroad pantograph, railroad catenary, dynamics, power collection, GE-625 computer, nonlinear mechanics, current-collecting

INFORMATION PREPARED FOR:

Mechanical Technology Laboratory

4 (5/66)

AIEE
Technical Paper
50-246

August 1950
Litho in USA

TRANSPOSITIONS AND THE CALCULATION OF INDUCTANCE FROM GEOMETRIC MEAN DISTANCES

W. B. Boast
Member AIEE
Iowa State College
Ames, Iowa

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A paper recommended by the AIEE Committees on Basic Sciences and Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Oklahoma City, Okla., October 23-27, 1950. Manuscript submitted March 8, 1950; made available for printing August 25, 1950.

PRICE: 30¢ To Members
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AIEE
Technical Paper
51-226

May 1951
Litho in USA

Math.

DETERMINATION OF INSTANTANEOUS CURRENTS AND VOLTAGES BY MEANS OF ALPHA, BETA, AND ZERO COMPONENTS

W. C. Duesterhoeft
Associate AIEE
University of Texas
Austin, Texas

Max W. Schulz, Jr.
Nonmember AIEE
General Electric Company
Pittsfield, Mass.

Edith Clarke
Fellow AIEE
University of Texas
Austin, Texas

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Mr. Frey

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OCT 15 1952
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OCT 13 1952
J. W. SEAMAN

POWER-REACTIVE DIAGRAMS STILL USEFUL

R. M. Butler

Electric Utility Engineering Divisions
General Electric Company
Schenectady, N. Y.

Reprinted from *Electric Light and Power*,
Vol. 30, July and August, 1952

GENERAL ELECTRIC

AIEE
Technical Paper
53-182

March 1953
Litho in USA

mails

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A DIRECT METHOD FOR SAG-TENSION CALCULATIONS

T. P. Harley
Associate Member AIEE
Bureau of Reclamation
Denver, Colo.

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A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Southern District Meeting, Louisville, Ky., April 22-24, 1953. Manuscript submitted September 8, 1952; made available for printing March 27, 1953.

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Technical Paper
53-401

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November 18, 1953

ELECTROSTATIC UNBALANCE TO GROUND OF TWIN CONDUCTOR LINES

Eric T. B. Gross
Fellow AIEE

W. J. McNutt
Associate Member

Both of:
Illinois Institute of Technology,
Chicago, Ill.

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EVALUATION OF THE INTEGRATION METHOD FOR ANALYSIS OF NON-STANDARD SURGE VOLTAGES

Andrew R. Jones
Associate Member AIEE
Westinghouse Electric Corp.
Industrial Atomic Power Section
Pittsburgh, Pa.

A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 21-25, 1954. Manuscript submitted March 24, 1954; made available for printing April 12, 1954.

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54-213

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Math

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ELECTROMAGNETIC UNBALANCE OF UNTRANSPOSED TRANSMISSION LINES, II.

SINGLE LINES WITH HORIZONTAL CONDUCTOR ARRANGEMENT

E. T. B. Gross
Fellow AIEE

S. W. Nelson
Nonmember AIEE

Both of:
Illinois Institute of Technology
Chicago, Ill.

A paper recommended by the AIEE Committee on Transmission and Distribution, and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27-July 1,1955. Manuscript submitted March 24, 1955; made available for printing May 9, 1955.

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A RATIONAL METHOD FOR THE STEP-BY-STEP CALCULATIONS IN POWER SYSTEM TRANSIENT STABILITY STUDIES

E. O. Norinder
Nonmember AIEE
Swedish State Power Board
Stockholm, Sweden

A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27-July 1, 1955. Manuscript submitted November 15, 1954; made available for printing May 11, 1955.

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55-479

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LABORATORY

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DIAKOPTICS

PIECEWISE SOLUTION OF LARGE-SCALE SYSTEMS

INTRODUCTION

AN INTRODUCTION TO UNIVERSAL ENGINEERING

by

Gabriel Kron

Report No. 57GL330 October 1957

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TRAVELING WAVE PROTECTION PROBLEMS — II

E. W. Boehne
Fellow AIEE
Massachusetts Institute of Technology
Cambridge, Mass.

A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27-July 1, 1955. Manuscript submitted March 29, 1955; made available for printing June 20, 1955.

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ERAN--TIME-SHARING STATISTICAL ERROR ANALYSIS FOR DESIGN TOLERANCES

by

W.B. Nelson and J.M. Miller*
Information Sciences Laboratory

Report No. 67-C-160

August 1967

*Member of Telecommunications and Information Processing Operations, Schenectady, N.Y.

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by

W. Nelson
Information Sciences Laboratory

Report No. 67-C-228

June 1967

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CLASS 2

HAZARD PLOTTING METHODS FOR ANALYSIS OF LIFE DATA WITH DIFFERENT FAILURE MODES

by

W. B. Nelson, Information Sciences Laboratory

Report No. 69-C-018

December 1968

ELECTRICAL DESIGN OF EHV SUBSTATIONS

L. O. Barthold
General Electric Company
Schenectady, N.Y.

and

J. B. Tice
General Electric Company
San Francisco, California

Presented at the Pacific Coast Electric Association
San Francisco, California, March 19-20, 1964

ADVANCED TECHNOLOGY LABORATORIES

AN ANALYSIS OF VARIANCE TEST FOR NORMALITY (COMPLETE SAMPLES)

BY

DR. S. SHAPIRO - GENERAL ELECTRIC CO.
DR. M. WILK - BELL TELEPHONE LABORATORIES, INC.

REPORT NO. 64GL140

SEPTEMBER 3, 1964

GENERAL ELECTRIC

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PROPOSAL

GENERAL ENGINEERING LABORATORY

Contamination

Evaluation of Arcing and Tracking Resistance of Insulation Surfaces at High Voltages by Direct and Indirect Test Methods

October 20, 1958

K. N. Mathes

GENERAL ELECTRIC

General Engineering Laboratory

Evaluation of Arcing and Tracking Resistance
of
Insulation Surfaces at High Voltages
by
Direct and Indirect Test Methods

October 20, 1958

K. N. Mathes

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SCHENECTADY, NEW YORK

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DEFENSE SUPPLY AGENCY
DAYTON, OHIO 45401

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REFER TO: DESC-EM

13 May 1966

Industry

MARKETING

Gentlemen:

The enclosed initial draft of proposed military specification MIL-I-23264A and associated specification sheets, project numbers 5970-0144 and 5970-0150 through 0174, are forwarded for review and comments. If the documents are of interest to you, it is requested that your reply be forwarded to this Center in sufficient time to arrive within 75 days from the date of this letter, with a copy to the preparing activity, Bureau of Ships, attention Code 621. Comments received subsequent to the requested date may be acted upon only if such action will not delay coordination; otherwise, all late comments may be held in abeyance for consideration during the next action involving this document.

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Reason - Enclosed data substantiate this change.

If further coordination is required, redrafts, compilation of comments, or invitations to attend meetings will be circulated only to firms and organizations that furnish comments or indicate by reply that they have an interest.

Further technical information related to the coordination of this document may be obtained by contacting the Defense Electronics Supply Center, attention DESC-EMM, Dayton, OH 45401.

Sincerely yours,

Richard A. Stimson

RICHARD A. STIMSON
Chief, Electro-Mechanical
Division

1 Encl
Initial Draft

DEFENSE ELECTRONICS SUPPLY CENTER
DEFENSE SUPPLY AGENCY
DAYTON, OHIO 45401

IN REPLY REFER TO: DESC-EQE-65-137

15 Feb 1965

General Electric Company
ATTN: Mr. B. E. Kingsbury
Insulator Department
2525 Insulator Drive
Baltimore, MD 21230

This Center is responsible for the administration of Qualified Products List for Military Specification MIL-I-10A, QPL-10. In order for this QPL to be of maximum utility to procurement activities, it is necessary that the listings and other information be as accurate and up-to-date as possible.

Accordingly, it is requested that you review the listings of your products and your address in the latest issue of QPL-10 (enclosed) and furnish the following information within 30 days of the date of this letter:

a. Any changes brought about by company mergers, corporate reorganizations or similar actions.

b. Any change in company name or plant location. (Please include your ZIP code and plant street address.)

c. Any change in product designation or composition.

d. Any products which are no longer manufactured.

e. One copy each of the latest "Periodic-batch-check inspection" (para 4.5.3 of MIL-I-10A) test reports for all materials which were qualified more than two (2) years prior to the date of this letter and which are still in production.

Sincerely yours,

Robert E. Cooper

ROBERT E. COOPER
Chief, Qualifications Division

1 Encl

Copy furnished:
EL

Conference Paper

A POLYMER INSULATOR FOR HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose
Senior Member IEEE
General Electric Co.
Baltimore, Md.

F. S. Nichols
General Electric Co.
Pittsfield, Mass.

A paper recommended by the IEEE Transmission and Distribution Committee for presentation at the IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Ont., Canada, June 16-21, 1963. Manuscript submitted March 26, 1963; made available for printing April 18, 1963.

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Paper No. CP
63-1039

Conference Paper

SOME CHARACTERISTICS OF POLYMER INSULATORS FOR HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose
Senior Member IEEE
General Electric Company
Baltimore, Md.

A paper recommended by the IEEE Transmission and Distribution Committee for presentation at the IEEE Winter Power Meeting, New York, N. Y., February 2-7, 1964. Manuscript submitted November 11, 1963; made available for printing December 20, 1963.

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Paper No. CP
64-36

Conference Paper

FIELD SERVICE TRIALS OF POLYMER INSULATORS FOR HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose
General Electric Co.
Baltimore, Md.

A paper recommended by the IEEE Transmission and Distribution Committee of the IEEE Power Group for presentation at the IEEE Summer Power Meeting, Detroit, Mich., June 27-July 2, 1965. Manuscript submitted April 6, 1965; made available for printing April 19, 1965.

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Paper No.
31 CP 65-663

FIELD SERVICE TRIALS OF POLYMER INSULATORS FOR HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose

SUMMARY

The first report on GEPOL® insulators for high voltage transmission lines was presented at the 1963 Summer Annual IEEE meeting in Toronto (CP-63-1039) and a second report on these insulators was presented at the IEEE Winter Power meeting in New York in 1964 (CP-64-36). These two papers reported on the original concept of a polymer insulator and the limited field trials of the insulator, as well as on the laboratory tests and characteristics of a revised design of the original polymer insulator. Since the publication of these two papers, the revised design has undergone extensive field service tests on the transmission lines of many utilities in the United States, under widely varied atmospheric conditions. This paper has been written as an interim report on the results of these field service tests and to present a detailed description of the insulators and the laboratory tests that have been made on insulators returned from field service, with varying periods of time in the field.

INTRODUCTION

In order to keep track of all parameters in this large scale field trial, the following steps were taken:

1. Each insulator manufactured was marked with a serial number. The date of its manufacture and conditions relating to the manufacturing process were recorded.

2. Each utility participating in the field trials was asked to return a questionnaire on the details of the installation of the insulators. This provided information on the date of installation, the voltage applied and any pertinent details concerning exposure, such as degree of contamination and kind of contaminants involved in the exposure.

3. Records were kept of the serial numbers of the insulators and the exposure as indicated by the returned questionnaires.

It was suggested to the sixty-eight utilities cooperating in the field trials that at least some of the exposure be made in severe locations so that a true cross-section of operating conditions would be obtained. Actually, of the approximately 1,700 insulators in service, a disproportionately high percentage was placed in areas involving severe contamination of various kinds.

The first insulators of this design were placed in service on field trial in October, 1963, and additional quantities have been put into service at intervals since then. Some of the 1,700 insulators presently in service have been operating for seventeen months and some of the more recent units have been in service for only a few months. The weighted average service time is probably about six months.

Of those insulators which have been placed in areas subject to abnormally severe contaminants, the contaminating materials covered a wide range including salt, gypsum, coal dust, fertilizer dust, fly ash, limestone, phosphates, acid fumes, cement, potash dust and heavy industrial contamination. In these field trials none of the insulators of this design were washed, even though in some cases porcelain insulators, when used in these same exposures, were subjected to regular washing operations.

In several cases the insulators were placed in areas which have been notorious for vandalism and where porcelain insulators were regularly broken by rifle fire.

Received from
Jesse Hunter
Jan 1965

PRELIMINARY COPY

PLASTIC SUSPENSION INSULATORS

J. C. Parker
Memphis Light, Gas, and Water Division

*

On a 115-kv overhead line feeding a chemical plant, we find corona on conventional 5 3/4" x 10" porcelain suspension insulators from time to time. This corona occurs only when these insulators are contaminated with matter originating in the plant and when their surfaces are also wet due to severe condensation, fog or mist. This corona has not resulted in a flashover or any damage, but it is a nuisance because when the plant operators see it they become alarmed and insist that we eliminate it before it results in a flashover that would interrupt their production.

The addition of two insulators to the nominal seven insulator strings we use on 115-kv lines did not appreciably improve this condition.

The contamination has the appearance of a deposit of fine white dust a few mils thick. It can easily be wiped off of the insulators, but a new deposit soon reappears.

Cleaning the insulators and applying Insulgrease eliminated this trouble for about a year. However, it was found to be difficult to remove from the insulators at the end of its useful life. The substitution of Insulcone for Insulgrease produced the same results and could easily be wiped off of the insulators at the end of its useful life. We realize that with different contaminants the performance of these two products will probably be different. Other brands of silicones of the same types will no doubt produce the same results.

Upon the insistence of a manufacturer that this annual maintenance could be eliminated by using his polymer insulators, we purchased six for a trial installation. These one-piece, 12-petticoat insulators were each supposed to be the equivalent of a string of seven standard ten-inch porcelain-suspension insulators. The delivered cost was approximately three times the cost of the equivalent standard insulators. These insulators were installed at random in the contaminated area. Their trouble-free life was approximately half that of porcelain insulators coated with Insulcone.

The polymer insulators have been removed and the manufacturer notified. His comments will be interesting.

Upon examining the polymer insulators after removal, about the same amount of contamination was found on them as on porcelain insulators. Tracking was found only at one point on one insulator. This tracking was confined to an area approximately 3/32" x 1/2" and was apparently over the end of the metallic fitting embedded in the end of the insulator. The depth of the tracking could not be determined without dissecting the insulator which was not considered advisable until the insulator is examined by the manufacturer. All of the insulators had rough spots of various sizes and shapes at random locations on their surfaces. There was no indication that these insulators would

Epoxy-Fiberglass Insulating Columns For Power Circuit Breakers

R. V. Klint, Laboratory Operation
Power Transmission Division, Philadelphia

ABSTRACT

Insulating columns having a structural tube of filament wound glass-epoxy, together with a filled cast epoxy outside covering combining weathering protection and creepage path, have been shown to be an excellent substitute for porcelain ceramic columns. These columns have been made in sizes applicable for 138 KV and 500 KV ATB Air Blast Circuit Breakers made by the Power Circuit Breaker Department.

Introduction

One of the major components in the air blast circuit breaker is a column of porcelain which supports the interrupting head above ground both electrically and physically. These columns must have capability to withstand high steady state and high impulse electrical stresses. Furthermore, by means of exterior convolutions sufficent creepage path is provided so that atmospheric contaminents will not permit electrical conduction between the high potential interrupting head and the ground.

Furthermore, these columns serve as structural members holding up the heavy steel casings containing the interrupting mechanisms. There are also extra loads due to pull of the transmission lines, wind and vibrational loading. Additionally there is a large axial load which is produced by the internal tie-rod construction which holds the interrupting head to the base of the circuit breaker. This is necessitated by the design using porcelain in which the porcelain column must be kept under compression for suitable mechanical performance; in addition, a high load must be applied to elastomer gaskets used in the sealing of high dielectric gases in the insulating column.

The use of a fiberglass wound structure to act as both the electrical and mechanical support for the interrupting head has been considered for some time. New advances in resin and glass winding technology have increased confidence that such a structure could be made to perform the required function satisfactorily, and, additionally, give the very long life that is required for use in utility apparatus. Evidence of satisfactory life has been obtained from the experience of the Insulator Department (Baltimore) which has had in service for over five years fiberglass reinforced, epoxy clad, transmission line tension supports. Other manufacturers have made many filament wound structures and have gained valuable experience in understanding how such reinforced composite structures can satisfactorily carry heavy loads.

DYNAMIC INSULATOR DUTY - CHAPTER 11

CONTROL OF CONDUCTOR VIBRATION DETER DYNAMIC LIFE-EXPECTANCY OF INSULATORS

Having explored extensively dynamic effects on insulators in previous chapters, it would seem desirable to summarize the question with some specific comments. These may sometimes appear in a degree of conflict. We feel sure, however, the reader will gather from the discussion at least an appreciation of the complexity of the subject.

Obviously there is a magnitude of vibratory deflection below which pin flexure is relatively harmless, and above which it is hazardous. Figures 1 and 2 depict typical examples of these conditions. Pin providing data for Figure 1 has a large diameter for most of its length, and necks-down to a shank of .72-inch diameter for a length of only .55-inch. (See Figure 3) This is an extreme case of reduced flexure in both length and diameter of the flexing member. Data in Figure 2 is typical of a pin with a diameter of .625-inch and an exposed length of 1.75-inch over which this diameter exists, giving it considerable flexure length. (See Figure 4) The difference in fatigue tolerance between the two pins is considerable.

Every pin design shows a typical range of tolerance, and the O-B laboratory has investigated most of the common pins now on the market. The data shows many differences resulting from pin conformation, but the general comparison between the shorter, less-flexible shank and the longer, more-flexible type is the most significant, and is presented in the two curves.

It will be noted in Figures 1 and 2 that mechanical load on the insulators is not an important factor, as indicated by the rather narrow dispersion of the line. Maximum service load is the common application assumption of 50 per cent of rated strength. Minimum load is the equivalent of a lightly loaded suspension point. For convenience, call this under 1,000 pounds. Bear in mind that in tangent points, load on the pin has little relation to conductor tension.

Fracture at the fillet line on the head of the pin of a ball-and-socket connection is a dynamic fatigue phenomenon, having only a second-order relation to static tensile load. While static load opens this fracture line more rapidly when it is established, it is not a primary factor in initiating the condition.

This being the case, why is conductor tension such an important consideration not only in strain but in tangent positions? It must be understood that pin damage is a function of aeolian vibration in the conductor. This vibration results from a "tuned" condition, and is affected by internal damping of the cable. Conductors strung below 15 per cent of their ultimate strength are basically self-damping, but very few such low tensions exist on modern EHV lines with long spans and generous ground clearances. Aeolian response of conductors is a subject far into the province of the cable manufacturer, and we will not presume to trespass on this territory. However, it is clearly delineated and we urgently recommend a thorough investigation as a part of preliminary line design.

We now reach a controversial point, namely, armor rods and vibration dampers. Like the umpire in a baseball game, we will call balls and strikes "as we see 'em" and may elicit some boos from the bleachers.

For the purpose of protecting the insulator string from damaging vibration, any damping device on the conductor must absorb energy in sufficient degree to fall within the limits outlined in Figures 1 and 2. We ignore the effect of such devices on the conductor . . . they may or may not be adequate to furnish protection for this member. We confine ourselves to the question of how much vibration generated in the open span will reach an insulator string.

According to conductor manufacturers, there are two general categories of armor rods, from an energy-absorption standpoint: (A) Either formed or straight, of continuous diameter. (B) Tapered, which change pitch when wrapped and set up inter-strand friction. The first type supplies no protection to the insulator string. The second provides a moderate degree of energy absorption.

Vibration dampers of accepted design are highly effective. We know of only one service failure of an insulator string protected by dampers. Dampers, in this case, were not installed for a short time after the line was built, and during this period a pin fracture was undoubtedly initiated. This fracture was then able to grow with the low level of vibration permitted by the dampers. Study of the fracture showed many progressive stages of its development.

Much of this discussion is predicated on a knowledge of amplitude and loop length in a vibrating string of insulators. Observation of these phenomena is extremely difficult. As was mentioned in the previous chapter, this observation is best done with a transit telescope which brings the viewer within a few feet of the insulator and provides a hair line as a reference point. This observation must be done from the side of the line because of orientation of the vibratory movement.

Even under ideal conditions, a string of insulators in vibration appears as no more than a blur at the antinode points, and accurate measurement of this fuzzy image

ELECTRICAL ENGINEERING

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Pumped storage hydroelectric plants—page 654

A high-power d-c/d-c static inverter—page 661

Buried urban telephone distribution—page 677

NOVEMBER 1963

Original Text for
IEEE Conference Paper CP 63-1039

A POLYMER INSULATOR FOR HIGH VOLTAGE TRANSMISSION LINES

By

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Presented at IEEE Summer General
Meeting June, 1963, in Toronto, Canada

A POLYMER INSULATOR FOR HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose F. S. Nichols

SUMMARY

Porcelain has been the principal insulating element in suspension insulators for many years. This paper describes how a modified epoxy type polymer with a fiberglass core is used in the design of a developmental suspension insulator for application on future transmission lines. Included in the paper is a resume of certain special tests run to prove the insulator, and a review of its current service record. The potential advantages of this type of insulator are summarized.

INTRODUCTION

Wet process electrical porcelain has been used in all types of suspension insulators for many years. Its long life, high dielectric strength, imperviousness to most chemicals, resistance to electrical tracking, and low materials cost have retained for porcelain a unique position as the insulating element in suspension insulators. There are probably over a hundred million porcelain suspension insulators in service today in the United States. Some of these have been providing reliable service over the span of many decades. For these reasons, efforts to replace the porcelain with other materials has so far been significantly unsuccessful.

Voltages and mechanical loads on insulators are increasing as the trends toward higher voltages, use of large conductors, multiple conductors and longer spans continue. These factors bring increasing need for higher reliability in materials and components for use in transmission lines. The need for an even better suspension insulator to meet these requirements becomes readily apparent. These needs can be defined in terms of practical design consideration.

1. A lighter but stronger insulator would facilitate construction and hot line maintenance.

2. An insulator with a much higher resistance to impact would reduce the susceptibility to breakage during handling and erection, and also would reduce outages caused by rifle fire and other accidental and malicious impacts during normal operation.

3. Puncture proof insulators, with the ability to sustain power arc follow currents without damage, would reduce outages due to lightning and switching surges, and would eliminate dropped lines caused by puncture induced explosion forces.

Early in 1954, a program was initiated by the General Electric Company to find an insulating material for use in outdoor insulators which would provide maximum reliability consistent with the utility industry's future requirements. Literally hundreds of formulations were investigated and tested. Finally, in 1957, a modified epoxy type polymer which appeared to meet our requirements for outdoor service was developed.

To fully explore the possibilities was a time-consuming process. It involved a great variety of investigations and tests to truly understand the characteristics of this material and to develop means of designing practical insulators with it as a base. When working with any new material for application to the exacting requirements of high voltage insulators, one must put aside preconceived ideas. Many of the design and test criteria presently applied to porcelain insulators are either meaningless or inadequate when applied to materials having entirely different characteristics. Other

Conference Paper

SOME CHARACTERISTICS OF POLYMER INSULATORS FOR HIGH VOLTAGE TRANSMISSION LINES

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A paper recommended by the IEEE Transmission and Distribution Committee for presentation at the IEEE Winter Power Meeting, New York, N. Y., February 2-7, 1964. Manuscript submitted November 11, 1963; made available for printing December 20, 1963.

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64-36

FIELD SERVICE TRIALS OF POLYMER INSULATORS FOR HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose

SUMMARY

The first report on GEPOL® insulators for high voltage transmission lines was presented at the 1963 Summer Annual IEEE meeting in Toronto (CP-63-1039) and a second report on these insulators was presented at the IEEE Winter Power meeting in New York in 1964 (CP-64-36). These two papers reported on the original concept of a polymer insulator and the limited field trials of the insulator, as well as on the laboratory tests and characteristics of a revised design of the original polymer insulator. Since the publication of these two papers, the revised design has undergone extensive field service tests on the transmission lines of many utilities in the United States, under widely varied atmospheric conditions. This paper has been written as an interim report on the results of these field service tests and to present a detailed description of the insulators and the laboratory tests that have been made on insulators returned from field service, with varying periods of time in the field.

INTRODUCTION

In order to keep track of all parameters in this large scale field trial, the following steps were taken:

1. Each insulator manufactured was marked with a serial number. The date of its manufacture and conditions relating to the manufacturing process were recorded.

2. Each utility participating in the field trials was asked to return a questionnaire on the details of the installation of the insulators. This provided information on the date of installation, the voltage applied and any pertinent details concerning exposure, such as degree of contamination and kind of contaminants involved in the exposure.

3. Records were kept of the serial numbers of the insulators and the exposure as indicated by the returned questionnaires.

It was suggested to the sixty-eight utilities cooperating in the field trials that at least some of the exposure be made in severe locations so that a true cross-section of operating conditions would be obtained. Actually, of the approximately 1,700 insulators in service, a disproportionately high percentage was placed in areas involving severe contamination of various kinds.

The first insulators of this design were placed in service on field trial in October, 1963, and additional quantities have been put into service at intervals since then. Some of the 1,700 insulators presently in service have been operating for seventeen months and some of the more recent units have been in service for only a few months. The weighted average service time is probably about six months.

Of those insulators which have been placed in areas subject to abnormally severe contaminants, the contaminating materials covered a wide range including salt, gypsum, coal dust, fertilizer dust, fly ash, limestone, phosphates, acid fumes, cement, potash dust and heavy industrial contamination. In these field trials none of the insulators of this design were washed, even though in some cases porcelain insulators, when used in these same exposures, were subjected to regular washing operations.

In several cases the insulators were placed in areas which have been notorious for vandalism and where porcelain insulators were regularly broken by rifle fire.

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June 2, 1965

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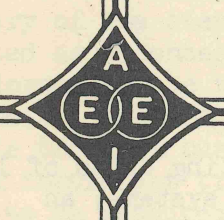
Conference Paper



THE DEVELOPMENT OF POWER FACTOR MEASUREMENT OF INSULATION IN THE FIELD

E. H. Povey
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A paper recommended by the AIEE Special Instruments and Auxiliary Apparatus Committee for the AIEE Winter General Meeting, New York, N. Y., February 2-7, 1958. Manuscript submitted October 14, 1957; made available for printing November 19, 1957.

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Mr Kingsbury

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Insulator Dept.
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Equipment Testing

GENERAL ELECTRIC
Research Laboratory

CAPACITANCE BRIDGE BALANCER

by

D. A. Felton and P. G. Frischmann

Report No. 56-RL-1616 September 1956

CLASS 2

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GAGE HISTORY NO:

GAGE I.D. NUMBER :
LOCATION :
CALIBRATION INT. :

GAGE SUPPLIER :
DATE ACQUIRED :

DESCRIPTION :
DRAWING # :
NEXT CAL. :

CAL. STANDARD :
GAGE ACCURACY :

CALIBRATION PROCEDURE:

CALIBRATION HISTORY

CURRENT STATUS:

TYPE	DATE	COMMENTS

LAST CALIBRATION DATA

DATE:

BY:

CHARACTERISTIC	ACTUAL	CHARACTERISTIC	ACTUAL

COMMENTS:

SERIAL # OF MASTER:

WHERE USED:

Transactions Paper

(Reviewed and Accepted for Publication)

SWITCHING SURGES AND ARRESTER AND GAP PERFORMANCE

DURING 220 KV LINE-DROPPING TESTS

W. N. Rothenbuhler
Southern California Edison Co.
Los Angeles, Calif.

D. D. Wilson
Associate Member AIEE
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Schenectady, N. Y.

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DEVELOPMENT OF POWER VACUUM INTERRUPTERS

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F. L. Lawton
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SOME FUNDAMENTAL ASPECTS OF RECOVERY VOLTAGES

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RADIO NOISE AGING CHARACTERISTICS OF SMALL ALUMINUM CONDUCTORS

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FUNDAMENTAL ASPECTS OF SOME SWITCHING OVERVOLTAGES ON POWER SYSTEMS

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FAULT AND LOAD CURRENT TESTING OF A BUNDLE CONDUCTOR SPACER

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Conference Paper

THE DESIGN AND TESTING OF AIR SWITCHES ABOVE 345KV

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62-285

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RESULTS FROM THE FIRST YEAR OPERATION OF PROJECT EHV

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Conference Paper

PROJECT EHV - THE VALUE OF RESEARCH

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AIEE Winter General Meeting
January 29, 1962

Paper No. CP
62-424

Conference Paper

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Schenectady, New York

AIEE Winter General Meeting
January 29, 1962

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EHV

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Chattanooga, Tenn.

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RESULTS FROM THE FIRST YEAR OPERATION OF PROJECT EHV

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by

L.F. Coffin, Jr., Metallurgy and Ceramics Laboratory

Report No. 66-C-211

July 1966

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ABSTRACT

FOR USE OF G-E EMPLOYEES ONLY

GENERAL ELECTRIC

TRANSFORMER AND ALLIED PRODUCTS DIVISION

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H. Fehlmann H Fehlmann	1. L.A.-Line Station and H.V. 2. L.A. - Testing 3. Insulators	59PT157 DATE 12/9/59

TITLE

CONTAMINATION TEST ON LIGHTNING ARRESTER HOUSINGS

ABSTRACT

Sixty-cycle flashover tests were made on L.A. housings with three variations of both housing diameter and number of petticoats. In addition to fog tests with 0%, 3%, and 10% salt solutions, standard dry and wet tests were made. Also tested were a 79 kv Ohio Brass L.A. housing and 7785 pin type insulators.

G.E. CLASS	REPRODUCIBLE COPY FILED TECHNICAL DOCUMENTS	NO. PAGES
IV		
GOV. CLASS		
None	Pittsfield, Mass.	54

CONCLUSION

1. Under contaminated conditions the withstand voltage increased and the leakage current decreased with the number of petticoats.

2. The Ohio Brass housing and the 7785 insulator supports had significantly higher withstand values under salt spray contamination than the G.E. housings. This appears to be the result of both increased creepage length and different design.

More detailed conclusions are given at the end of the report.

By cutting out this rectangle and folding on the center line, the above information can be fitted into a standard card file.

For list of contents-drawings, photos, etc. and for distribution see reverse side.

INFORMATION PREPARED FOR Lightning Arrester/W.J. Rudge

TESTS MADE BY JS Bozyczko, JE Eulian, HR Fehlmann Tests Completed: 9-24-59

COUNTERSIGNED F.J. Turner F J Turner SECTION High Voltage Laboratory

BUILDING and ROOM No. #9 - Rm. 102 LOCATION Pittsfield, Mass.

/hrq

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR	SUBJECT CLASSIFICATION	NO.
J. P. Benedict JP Benedict	1. L.A.-Line Station and H.V. 2. L.A.-Testing 3. Insulators	60PT145 DATE 7/6/60

TITLE

CONTAMINATION TEST ON SIX TYPES OF DEVELOPMENTAL LIGHTNING ARRESTER HOUSINGS. PHASE II

FOR USE OF G-E EMPLOYEES ONLY

GENERAL ELECTRIC

TRANSFORMER DIVISION

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR	SUBJECT CLASSIFICATION	NO.
J.P. Benedict JP Benedict	1. L.A.-Line Station and H.V. 2. L.A.-Testing 3. Insulators	60PT145 DATE 7/6/60

TITLE: CONTAMINATION TEST ON SIX TYPES OF DEVELOPMENTAL LIGHTNING ARRESTER HOUSINGS. PHASE II

ABSTRACT: Sixty-cycle flashover tests were made on developmental L.A. housings having various hood configurations. In addition to fog tests with 0% and 3.8% salt solutions, standard dry and wet tests were made. Also tested were a 79 kv Ohio Brass L.A. housing, a 9LA3K066 housing and 7785 cap and pin type insulators.

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CONCLUSION

1. On the basis of these tests, two designs appear to be best suited for application in contaminated areas. They are:

   a. Lightning arrester housings having 14 hoods with the underside corrugated.

   b. Lightning arrester housings having 15 hoods with a 15 degree undercut.

2. The ability of these lightning arrester housings to withstand 10 cycles of 3.8 percent salt solution fog at 50 kv appeared to be a function of design profile rather than the total creepage length or the ratio of protected creepage length to the total creepage length.

By cutting out this rectangle and folding on the center line, the above information can be fitted into a standard card file.

For list of contents-drawings, photos, etc. and for distribution see reverse side.

INFORMATION PREPARED FOR Lightning Arrester / W.J. Rudge

TESTS MADE BY HR Fehlmann, JE Eulian, and JP Benedict Tests Completed: 6/13/60

COUNTERSIGNED AF Rohlfs A F Rohlfs SECTION High Voltage Laboratory

BUILDING and ROOM No. 9-102 LOCATION Pittsfield, Massachusetts

-mjb

Mechanics - Fracture

GENERAL ELECTRIC

Research Laboratory

PHYSICAL NATURE OF PLASTIC FLOW AND FRACTURE

by

J. J. Gilman

Report No. 60-RL-2410 M

April 1960

CLASS 1

SCHENECTADY, NEW YORK

GENERAL ELECTRIC

RESEARCH AND DEVELOPMENT CENTER

SCHENECTADY, NEW YORK

CLASS 1

FRACTURE MECHANISMS IN ELECTRICAL INSULATOR PORCELAINS

by

G.E. Kluwe, Jr. and R.C. Anderson, Metallurgy and Ceramics Laboratory

Report No. 68-C-385

October 1968

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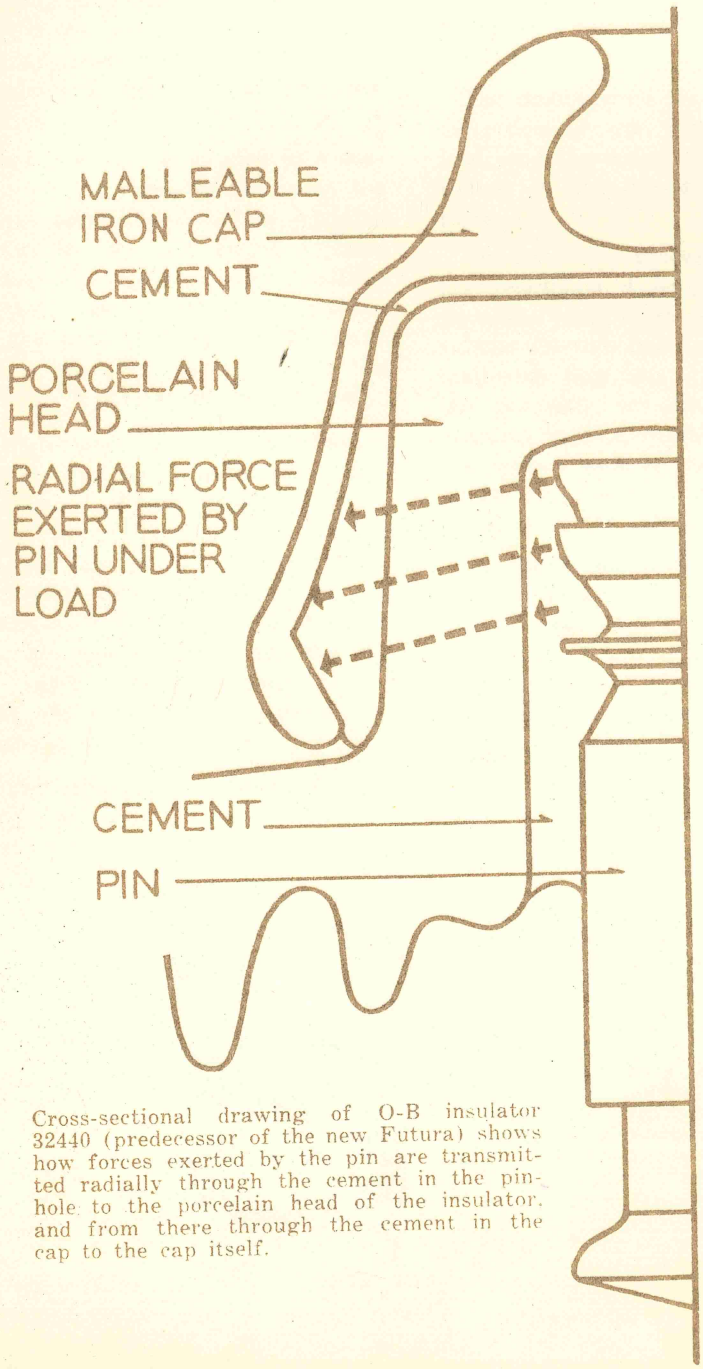
SEP 29 1961
G. M. BOYD

how the development of improved research tools aided the development of an improved insulator design

EDITOR'S NOTE: Since the introduction of the Futura insulator last July, our efforts in this publication have been directed primarily toward a more complete explanation of the substantial benefits users should expect from this insulator as a result of the incorporation of the Corrosion Interceptive

FUTURA A NEW DESIGN



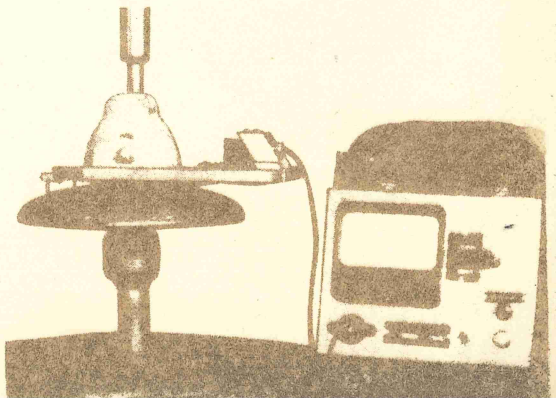
Cross-sectional drawing of O-B insulator 32440 (predecessor of the new Futura) shows how forces exerted by the pin are transmitted radially through the cement in the pin-hole to the porcelain head of the insulator, and from there through the cement in the cap to the cap itself.

Among the early problems confronting O-B engineers in their search for an improved insulator design was the problem of determining -- more precisely and more accurately than ever before -- what actually happens to an insulator when it is subjected to various types of mechanical and electrical loads and stresses.

Conventional tools and tests, techniques and instrumentation, were frequently too crude to probe many of the areas they wanted to explore more thoroughly.

They had to develop, for example, a new technique of impulse testing, new instrumentation to record fast waves (of the order of .01 micro-seconds), improved ways to measure the deflection of porcelain under mechanical load, and other new laboratory aids.

Some of the new tools they developed will be revealed for the first time in future technical papers: others will be discussed in this publication.



Mechanics

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Conference Paper

ALUMINUM COLD FLOW COMPENSATION IN BOLTED ELECTRICAL CONNECTIONS

G. L. Flynn
Nonmember AIEE

T. L. Rundlett
Member AIEE

Both of:
Anderson Electric Corp.
Birmingham, Ala.

RECEIVED
AUG 8 1961
H. A. EREY

A paper recommended by the AIEE Transmission and Distribution Committee for presentation at the AIEE Pacific General Meeting, Salt Lake City, Utah, August 23-25, 1961. Manuscript submitted May 25, 1961; made available for printing June 23, 1961.

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Paper No. CP
61-940

Mechanics

BASIC CONCEPTS IN THE DESIGN OF ELECTRICAL BUS FOR SHORT CIRCUIT CONDITIONS

A. C. Bates

INTRODUCTION

The adequacy of the mechanical structure of an electrical bus to withstand short circuit forces has been an engineering consideration for many years. During this time the problem must have occupied the attention of many capable engineers, and as a result one would expect to find a basic knowledge of the subject widespread. However this does not seem to be true. Possibly this is because there may have been insufficient economic pressure to cause a deviation from an over simplified method which resulted, fortunately, in an over strong structure. Another possible reason is that the subject demands both electrical and mechanical analysis. Unfortunately, the electrical engineer tends to drop his careful thinking once the electrical considerations are analyzed, and the mechanical engineer may have trouble in making an adequate analysis because of insufficient knowledge of the electrical origin of the problem. Whatever the reason, confusion seems to exist, and the purpose of this paper is to make an earnest attempt to contribute information which will lead to an appreciation of the basic elements of the problem.

LIMITATION OF TREATMENT

There are many questions which might be asked about the design of a new bus structure for an intended service, or the analysis of the adequacy of an old one for a new service condition. The answers to such questions must result from an analysis, and hence must be deferred until at least some acceptably approximate analysis has been made.

It is necessary drastically to limit the subject matter in order to permit a grasp of the elementary aspects of the problem. For this purpose, a single phase circuit employing parallel conductors on rigid supports has been chosen.

THE CIRCUIT, CURRENT, AND FORCE

An ideal single phase circuit is shown in Fig. 1. The R and X are the total resistance and reactance involved in the current flow, and E is an ideal voltage source having no impedance. It is assumed that the switch is closed at the time necessary to produce the greatest initial offset of the current wave. With i representing the instantaneous value of current, and I_{sp} the peak value of symmetrical or steady state current, the offset wave may be expressed as:

$$\frac{i}{I_{sp}} = e^{-\frac{R}{X}\omega t} - \cos\omega t \qquad (1)$$

Charlie Q

MEMORANDUM

TO: All Supervisors

FROM: Paul Ankrim

SUBJECT: Roof Leaks Survey Report

DATE: May 3, 1989 (Wednesday)

==========

Attached are three different reports (six sheets of paper) relating to the factory leaks that were reported by Locke supervisors.

Each leak has a unique number and locator number. The number in most cases takes the Department Number and adds to it sequential two-digit numbers beginning with 01. Hence, for example, leak Number 02001 is the first leak reported by the Shipping Department.

Only the Ceramics Lab and High Voltage Lab have a different numbering system in this survey. (The specially prepared map for the Ceramics Lab is not attached to this report.)

The attached map records 68 of the 79 leaks' approximate positions. Those of the Ceramic Lab and High Voltage Lab are not plotted.

Please see the attached data recording form for understanding the various headings such as "Prior#1," "other-des," etc.

The reports are:

1. "Leaks Summary, All Fields--this provides an overview of all responses.

2. Three reports providing detailed information about leaks in each of the three classifications. The number of each classification is as follows:
    a. Dangerous: 24 (30.4 %), of which eight are in department 165 and four are in department 169.
    b. Hazardous: 21 (26.6 %), of which four are in department 161.
    c. Damaging: 34 (43.0%), of which half are equally shared by departments 020 and the ceramic lab.

Thank you very much for your cooperation in completing this survey. Perhaps you will discover leaks or condensation that are not recorded, especially from pipes, drain leaders, heaters, air conditioning tubes, etc. Please provide that information at your convenience.

Documenting the leaks was the easiest step; making the repairs is the real challenge, but you have my assurance that these will be made as efficiently and timely as possible.

INDEX FOR: POLYMER

Number	Title	Author	Company	Date
1796-63-8	BASIC TEXT OF PRESENTATION ON NEW POLYMER INSULATOR HIGH VOLTAGE TRANSMISSION LINES AT PRESS MEETING ON MAY 8, 19633	Peltosalo, A.E.	Insulator Dept Baltimore, MD General Electric	5/8/1963
Memo	Test to determine relative resistance of several insulating structures to gunfire	Sweeney, JO	Insulator Dept. GE Baltimore, MD	3/26/1963
IEEE CP 63-1039	A POLYMER INSULATOR FOR HIGH VOLTAGE TRANSMISSION LINES	Vose, FC Nichols, FS	General Electric Balto & Pittsfield	3/26/1963
Paper	A NEW THOUGHTS ON HIGH VOLTAGE INSULATORS	Frey, HA	GE-Insulator Dept	
IEEE CP 64-36	SOME CHARACTERISTICS OF POLYMER INSULATORS FOR HIGH VOLTAGE TRANSMISSION LINES	Vose, Fred C.	GE-Insulator Dept Baltimore, MD	11/11/1963
Advertisement	NEW GENERAL ELECRIC TERMI-MATIC		General Electric	
IEEE CP 31 CP 65-663	FIELD SERVICE TRIALS OF POLYMER INSULATORS FOR HIGH VOLTAGE TRANSMISSION LINES	Vose, Fred C	GE-Insulator Dept Baltimore, MD	4/6/1965
Paper	USE OF FIBERGLASS IN CONSTRUCTION OF TRANSMISSION LINES	Jerome, FD		10/5/1966
Paper	EPOXY HIGH VOLTAGE INSULATORS FOR OUTDOOR USE	Wheeler, Edw S	GE-Insulator Dept	4/6/1967
Excerpt IEEE	CONCEPT & ANALYSIS OF EPOXY-CERAMIC INSULATOR SYSTEM FOR OVERHEAD LINES	Halley, Hugh G Popeck, Chas. A.	IEEE members	December 1967
Copy	HI-LITE INSULATORS ARE COMPARED TO PORCELAIN IN THEIR STRENGTH-TO-WEIGHT RATIO		Ohio Brass	
Discussion Paper	MECHANICAL RATINGS ON NON-CERAMIC INSULATORS Paper for WG on Nonceramic & Composite Ins.	Holte, Kirby C. Moleff, Ted	So. Calif Edison	
Paper	CHARACTERISTICS OF FIBERGLASS AND POLYMER INSULATION	Wheeler, Edw S	General Electric Baltimore, MD	
TR LK-864	COMPOSITION OF LOW VOLTAGE POLYMERIC INSULATORS MARKETED BY OUR COMPETITORS FOR INDOOR USE	Nichols, G.	General Electric Blatimore, MD	2/2/1968

1796-63-8

Basic Text of Presentation on New Polymer Insulator for High Voltage Transmission Lines at Press Meeting on May 8, 1963 at Park Lane Hotel, New York City

Arthur E. Peltosalo, General Manager
Insulator Department
General Electric Company
Baltimore, Maryland

General Electric announces Phase 3 of its long range program to provide uniquely different insulation systems for high voltage electric power systems. Phase 3 is pilot production of fiber-glass polymer suspension insulators (Company trademark is GEPOL) in cooperation with electric utility systems who will make trial installations in 1963-64.

The initial phase of this research program was the development of the material and process for an experimental insulator model. The second phase involved limited field test installations, along with continued process development in perfecting the initial experimental models.

-more-

Conference Paper

A POLYMER INSULATOR FOR HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose
Senior Member IEEE
General Electric Co.
Baltimore, Md.

F. S. Nichols
General Electric Co.
Pittsfield, Mass.

A paper recommended by the IEEE Transmission and Distribution Committee for presentation at the IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Ont., Canada, June 16-21, 1963. Manuscript submitted March 26, 1963; made available for printing April 18, 1963.

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Paper No. CP
63-1039

NEW THOUGHTS ON HIGH VOLTAGE INSULATORS

H. A. Frey, Mgr.-Engineering

Insulator Department General Electric Company

I very much appreciate this opportunity to present to the Electrical Equipment Committee some of the new thoughts on materials for high voltage insulators, and the problems associated with such material.

I know that your Committee's primary interest lies in electrical equipment and apparatus insulation rather than line insulation. However, in these two areas the fundamental insulating material problems are interchangeable so that I hope you will understand if many of my remarks are directed toward line insulators, since it is in this area that we have much of our total experience with some of the new materials for high voltage outdoor insulation.

Virtually all high voltage insulators, whether used in apparatus or as line insulation, must perform three basic functions:

1. They must provide mechanical support and so they must have mechanical strength consistent with their expected service load.
2. They must have adequate dielectric strength to support line voltage plus expected overvoltages due to surges.
3. They must be so designed as to make efficient electrical use of the surrounding medium, which in the case of outdoor insulators is air.

In the most general sense, the basic requirements for the materials of which high voltage outdoor insulators are made are shown in the following tabulation.

Conference Paper

SOME CHARACTERISTICS OF POLYMER INSULATORS FOR HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose
Senior Member IEEE
General Electric Company
Baltimore, Md.

A paper recommended by the IEEE Transmission and Distribution Committee for presentation at the IEEE Winter Power Meeting, New York, N. Y., February 2-7, 1964. Manuscript submitted November 11, 1963; made available for printing December 20, 1963.

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64-36

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Dependable indoor terminations are prepared in less than two minutes using the TERMI-MATIC void-free, one piece, molded rubber stress cone.

General Electric combines the same stress cone with easy-to-apply modular, track-proof rubber skirts and waterproof cap to form the outdoor rubber termination system. And GE's outdoor TERMI-MATIC system withstands the most contaminated atmosphere, and even bounces—undamaged—if it's dropped! (There's an outstanding outdoor porcelain TERMI-MATIC system, too.)

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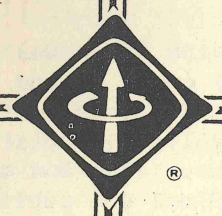
Conference Paper



FIELD SERVICE TRIALS OF POLYMER INSULATORS FOR HIGH VOLTAGE TRANSMISSION LINES

F. C. Vose
General Electric Co.
Baltimore, Md.

A paper recommended by the IEEE Transmission and Distribution Committee of the IEEE Power Group for presentation at the IEEE Summer Power Meeting, Detroit, Mich., June 27-July 2, 1965. Manuscript submitted April 6, 1965; made available for printing April 19, 1965.

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Paper No.
31 CP 65-663

REPRINTED WITH THE APPROVAL OF
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Make Copies & Send to:
~~Kaminski~~ -Frey- ~~Kingsbury~~
& ~~Rose~~ .

The use of Fiberglas in the construction of transmission lines has increased in the last few years as new ways of using this material are being discovered.

I would like to tell you of several ways that we at Carolina Power & Light Company are putting it to use on our transmission lines.

Since it has such a high insulating value we are trying to use it to raise the impulse level of the structure by replacing certain parts of the structure with the Fiberglas.

For example, on one of our older 115 KV double circuit tower lines we wished to improve the lightning performance of the line by increasing the insulation, but were unable to add additional insulators because of the limited airgap clearance between the top conductor and the middle crossarm brace. This clearance limited the number of insulators that could be installed.

In order to increase the airgap we are in the process of replacing the middle crossarm brace with Fiberglas braces.

These braces are to be ordered with a turnbuckle in one end. The turnbuckle is for the purpose of allowing the brace to be delivered with the normal manufacturing tolerances as to length. Unless special procedures are used to obtain an exact length for the Fiberglas brace, the tolerances would be too large for the brace to be substituted for the metal brace on the arm. The turnbuckle provided a convenient means of adjusting the length to fit the tower. These braces cost about $12.00, and allow us to increase the number of insulators from 7 to 9. The replacing of the brace is done at the same time we reconductor the line.

On wood H-frame lines the same Fiberglas brace with built-in turnbuckle can also be used as outside knee braces to support the ends of the crossarm.

EPOXY HIGH VOLTAGE INSULATORS FOR OUTDOOR USE

Edward S. Wheeler
Manager-Engineering
General Electric Company
Insulator Department
Baltimore, Maryland

For presentation at the Symposium

"HIGH VOLTAGE APPLICATIONS OF EPOXIDE RESINS"

The University of Manchester
Institute of Science and Technology
Manchester, England

April 6, 1967

with which it can make a bilateral schedule change; it is desired to balance out for total inadvertent in each area; if the algebraic sum of all inadvertent around the interconnection is or can be made zero, full balance between areas can be achieved; and, if it is not or can not be made zero, then there is a residual amount of inadvertent that is uncorrectable, and the equitable thing to do is to distribute it among all areas in proportion to their size.

The suggested technique is for all areas, at regular and previously stipulated times and for previously stipulated periods, to reset their net interchange schedules to eliminate their respective inadvertent accumulations during the stipulated period. This would be done universally and regularly, on a system-wise basis, at hourly or other time intervals, and for stated time periods which could even be the full hour. To the extent that areas can respond to these reset schedules, inadvertent accumulations would be corrected.

If the algebraic sum of all inadvertents were indeed zero, as several of the discussers suggest it would be, then the algebraic sum of schedule offsets would be zero, and frequency would not be influenced as inadvertent accounts were being automatically reduced to zero. If it turned out that the algebraic sum of inadvertents were not zero, then there is an uncorrectable residual inadvertent. The algebraic sum of schedule offsets would not be zero, and a small frequency deviation would develop, sufficient to spread the uncorrectable accumulation uniformly among all areas in proportion to their bias settings.

To simplify matters for system operators, and to avoid confusion with normal interchange schedule settings, separate setting dials could be used for the inadvertent correction setting. In each case it could be calibrated directly in terms of the inadvertent accumulation to be corrected, with appropriate allowance for the stipulated time allocated to the correction. Suitable megawatt constraints and frequency limits within which the corrections would be effective could be applied.

It is recognized that the suggested technique would require regularly scheduled concerted setting action on the part of all areas. Perhaps operating areas would not regard this as a greater burden than system-wide concerted resetting of frequency schedules for time error correction, particularly since the inadvertent accumulation correction action would be taken at regular times on a universal system-wide programmed basis.

In closing, I again wish to thank the several discussers for their thoughtful and penetrating comments.

References

[1] B. Littman and T. S. Chen, "Simulation of Bull Run supercritical generation unit," *IEEE Trans. Power Apparatus and Systems*, vol. PAS-85, pp. 711–722, July 1966.

[2] J. Adams, D. R. Clark, J. R. Louis, and J. P. Spanbauer, "Mathematical modeling of once-through boiler dynamics," *IEEE Trans. Power Apparatus and Systems*, vol. PAS-84, pp. 146–156, February 1965.

[3] R. R. Walker and W. H. Baker, "Control response of once-through steam generators," presented at the 1966 IEEE Winter Power Meeting.

[4] D. J. Ahner, C. E. Dyer, F. P. deMello, and V. C. Summer, "Analysis and design of controls for a once-through boiler through digital simulation," *Ninth Nat'l Power Instrumentation Symp., ISA Proc.* pp. 11–30, May 16–18, 1966.

[5] A. A. Ward and R. L. Stubbins, "Control testing on rapid load changes of the supercritical boiler at Alamitos Steam Station Unit 5," presented at the 1966 ASME Winter Annual Meeting.

Concept and Analysis of Epoxy–Ceramic Insulation System for Overhead Lines

HUGH G. HALLY, SENIOR MEMBER, IEEE, AND CHARLES A. POPECK, SENIOR MEMBER, IEEE

Abstract—**A new insulation system for overhead electric lines is presented, together with the system concept and analysis of testing and development data upon which specific designs and application of epoxy–ceramic assemblies (ECA) have been based. For the purposes of data presentation and application referral, the discussion is directed principally toward transmission voltages of 69 kV and above. However, the system presented applies to the lower voltages as well.**

Present Problems and Needs

THE NEED for improved and more sophisticated insulation techniques for overhead systems is becoming increasingly apparent as the problems of "beautility," reliability, right of way, higher voltages, and underground are brought into focus in practical and economic relationships. The ECA insulation system is proposed as a major step toward fulfillment of such needs by providing shorter arm lengths and shorter suspension insulator string length.

Paper 31 TP 66-401, recommended and approved by the Transmission and Distribution Committee of the IEEE Power Group for presentation at the IEEE Summer Power Meeting, New Orleans, La., July 10–15, 1966. Manuscript submitted April 11, 1966; made available for printing June 14, 1967.

The authors are with the A. B. Chance Company, Centralia, Mo.

In many situations, the most realistic alternative to heavy investment in new overhead or underground facilities and right of way is the upgrading of the existing overhead plant to higher capacity through conversion to higher voltages. Of prime consideration in such ventures is the preservation of existing right of way boundaries, the appearance of the converted structures, and the adequacy of the line insulation to give satisfactory performance.

Traditional overhead construction consisting of wood–porcelain or steel–porcelain combinations has a long history, but it has not been without its problems. Pole fires, crossarm burning, and uncertainties in impulse levels and insulation coordination have caused greater spacings and more insulation to be provided than might otherwise be required.[1] With voltage levels gradually increasing over the years, overall economic and practical considerations indicate the necessity for departures from former practices.

The search for new insulating materials and techniques for overhead line construction has been going on for several decades. Until recent years, however, the lack of sufficient and accurate information regarding the performance characteristics of conventional construction has slowed the efforts toward a more sophisticated insulation system.[2]

Overhead line construction and insulation techniques now seem to be entering a new era. Vastly increased testing facilities,

MECHANICAL RATINGS OF NON-CERAMIC INSULATORS

DISCUSSION PAPER

FOR

WG on Non-Ceramic and Composite Insulators for Transmission Lines

Discussion Prepared

by

Kirby C. Holte

Ted Moleff

Southern California Edison

CHARACTERISTICS OF FIBERGLASS AND POLYMER INSULATION

Edward S. Wheeler
General Electric Company
Baltimore, Maryland

INTRODUCTION

Although today we tend to think that porcelain line insulation has always given satisfactory operation, there really are several things historically not quite right with that point of view. For the first thirty years or so of its use, porcelain insulation was unreliable all too frequently. Fortunately, utilities and manufacturers alike learned the problems of porcelain, and designed the product and use of it to accommodate these shortcomings. Nowhere has that been truer than in suspension insulators. From the manufacturer's viewpoint, the product is slow to manufacture, heavy, and can be fragile if handled roughly. Designs and processes must reflect the inherent nature of the materials used. The utility is concerned with its bulkiness and weight, and must allow considerable warehouse space for its storage. The suspension insulator's arch enemy has historically been the gun carrying vandal, but more recently the ecologist has turned our attention to the appearance of its bulky profile, and the clutter on the pole top that can easily be caused with several porcelain discs in series.

Seventeen years ago we began to study outdoor high voltage insulation, asking whether some alternative might be found in the newer insulation materials. What developed from more than a decade of research and development has come to be known as the GEPOL® insulator. (Figure 1)

The GEPOL insulator is, properly speaking, a track-resistant, fiberglass reinforced polymer insulator. It depends for its electrical and mechanical integrity on a fiberglass reinforced central rod, about which is cast the track-resistant material, a flexibilized epoxy formulation.

It would have been possible to make a plastic insulator along these general lines twenty years ago. It would not have worked, however. Scientists and design engineers have known for many years that almost all organic materials will track when exposed to contamination and moisture outdoors in electrical service. Tracking may be defined as the formation of carbonaceous conducting paths on the surface of

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TECHNICAL REPORT LK-864

COMPOSITION OF LOW VOLTAGE POLYMERIC INSULATORS MARKETED BY OUR COMPETITORS FOR INDOOR USE

Author:

G. Nichols

G. Nichols
Polymer Engineer R&D

Distribution: ES Wheeler
FC Vose
J Kaminski
AJ Pezdek
KW Cermak
CD Croskey
JM Jesatko
G Nichols

Approved:

E. S. Wheeler 2/8/68

E. S. Wheeler
Manager-Engineering

General Electric Company Baltimore, Maryland February 2, 1968

POLYMER HIGH VOLTAGE INSULATORS FOR OUTDOOR USE

Edward S. Wheeler
Manager-Engineering

Presented at:

26th Annual Technical Conference
Society of Plastics Engineers, Inc.
New York, New York
May 10, 1968

Insulator Department General Electric Company Baltimore, Maryland

POLYMER HIGH VOLTAGE INSULATORS FOR OUTDOOR USE

Edward S. Wheeler
Manager-Engineering

Presented at:

26th Annual Technical Conference
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May 10, 1968

Insulator Department General Electric Company Baltimore, Maryland

POLYMER HIGH VOLTAGE INSULATORS FOR OUTDOOR USE

Edward S. Wheeler
Manager-Engineering

Presented at:

26th Annual Technical Conference
Society of Plastics Engineers, Inc.
New York, New York
May 10, 1968

Insulator Department General Electric Company Baltimore, Maryland

OUR FAMOUS FIRSTS IN THE FIELD OF ELECTRICAL INSULATION

1893	First Wet Process Porcelain Insulator
1896	First 60 KV Pin Type Insulator
1896	First Triple Petticoat Insulator
1897	First Helmet Type Insulator
1904	First Suspension Insulator
1904	First High Voltage Laboratory
1908	First Clevis Type Suspension Insulator
1908	First Radio Insulator
1908	First Nicholson Arcing Ring
1909	First Switch Insulator
1911	First Switch Insulator for High Voltage
1920	First Stack Type Switch Insulator
1929	First Major Improvement in Glaze
1931	First to Reglaze over the Sand Grip
1932	First Noiseless Pin Type Insulator
1934	First Hi-Top Insulator
1935	First Compression Glaze
1938	First Compression Sand for Cement Grip
1939-45	First Mat Glaze for Metallizing Porcelain for Hermetic Sealing
1939-45	First Vacuum Pressed Steatite
1947	Newest and Most Modern Ceramic Research Laboratory
1953	First Mechanized Manufacturing for Line Type Insulators
1955	First High Strength Ceramic Body for E.H.V. Applications
1956	First Ball and Socket Type 36,000 Lb. Suspension Insulator
1956	First 10" - 25,000 Lb. Suspension Insulator for 4-3/4" or 5" Spacing
1957	First 650 KV BIL Switch and Bus Insulator Stack
1957	First Combination Stacking Unit for Economical Strength Grading
1958	First Color Coding for Suspension Insulators
1958	First Spray for Silicone Grease - INSULJEL
1959	First Complete Line of Extra High Strength Stacking Switch Insulators
1959	First Rugged 6" Distribution Insulator
1959	First Polymer Suspension Insulator
1960	First Insulator String Designs for Large Scale 500 KV Line in U.S. - Penelec
1961	First Insulator String Designs for 770 KV Line - EHV Pittsfield
1963	First Polymer Insulator Laboratory and Pilot Shop
1964	First Polymer Insulators for EHV Station Equipment
1965	Installation of World's Tallest Kiln for EHV Porcelains
1966	First Shrouded Clevis Hardware Fitting for EHV Assemblies
1967	First Polymer Distribution Deadend Insulator
1967	First Catalog of Standard EHV Assemblies
1967	First (Joint G.E.-Bethea) D.C. - E.H.V. Hardware System
1968	First 80,000 Lb. Suspension Insulator in the U.S.

INSULATOR DEPT. • GENERAL ELECTRIC CO. • BALTIMORE, MD.

7-68

FN-610-A (12-65)

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GENERAL ELECTRIC

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR	SUBJECT	NO.
F.C.Vose K.N.Mathes L.J.Hogue	POLYMER HIGH VOLTAGE INSULATORS	68LK906
		DATE Nov. 1968
TITLE DEVELOPMENT OF ANTITRACKING GEPOL® HIGH VOLTAGE INSULATORS		G.E. CLASS 2
		GOVT. CLASS None
REPRODUCIBLE COPY FILED AT ENGINEERING SECTION INSULATOR DEPARTMENT BALTIMORE, MD.		NO. PAGES 10

SUMMARY

A technical paper presented at the Insulating Materials and Dielectric Behavior Technical Conference, Research and Development Center Auditorium, The Knolls, Schenectady, New York on November 13, 1968.

The evolution of the design and development of the General Electric Insulator Department's GEPOL high voltage insulators for transmission and distribution lines is covered from 1959 to the present. Many of the primary principles that should be applied in using polymeric materials for this application are covered. Results of field trials are presented. The various laboratory tests used to evaluate the antitracking characteristics of the organic materials used and the insulators developed are discussed.

KEY WORDS

INSULATORS, GEPOL

INFORMATION PREPARED FOR --

TESTS MADE BY --

AUTHOR Fred C Vose

COMPONENT Insulator Department; R&D Center

APPROVED Edward S. Wheeler

NGK TECHNICAL REPORT

No. 11—1969

NGK RESIN INSULATORS

NGK INSULATORS, LTD.
(Nippon Gaishi Kaisha, Ltd.)
MIZUHO, NAGOYA, JAPAN

NGK INSULATORS, LTD.
(Nippon Gaishi Kaisha, Ltd.)
MIZUHO, NAGOYA, JAPAN

RESIN INSULATOR

(Abstract of NGK Review No.27, Jan., 1969)

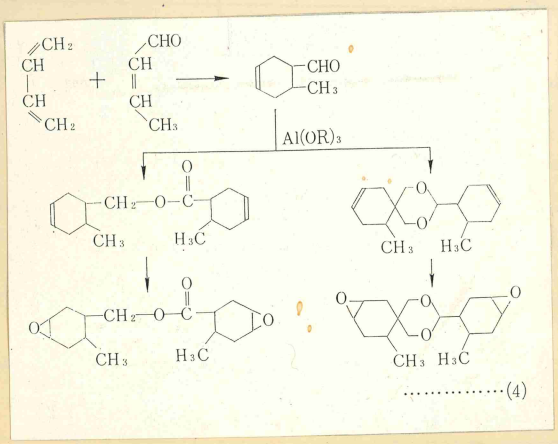
5. OUTDOOR RESIN INSULATORS

What has been said till now is all about indoor resin insulators which are made of bisphenol-type epoxy resin. This bisphenol-type epoxy resin contains in its structural formula benzene nucleus, because of which it lacks strength against tracking under outdoor polluted conditions.

It is reported that Outdoor Resin Insulators using a resin of this type have been put into trial service on transmission lines of some utilities in USA, but unfortunately within a year tracking occurred on the resin surface of some of these specimens.

Tracking is related to the "mobility" of electron and its characteristics vary according to the quantity of benzene nucleus and to the number of conjugate double bonds.

Our recent research revealed that for lack of benzene nucleus as shown in (4) formula, some formulation of cycloaliphatic type resin has excellent weatherability and anti-tracking characteristics, which make it feasible for outdoor use.



NGK INSULATORS, LTD.
MIZUHO, NAGOYA, JAPAN

April 26, 1974

To: LOCKE INSULATORS, INC.

MEMORANDUM

Sub.: Anti-tracking property of silicone insulators

It is reported in the brochure from the manufacturer that a RODURFLEX-insulator composed of a FRP core and silicone rubber sheds has good anti-contamination performance because of its water-repellency, slenderness and long surface creepage distance. We have no firsthand information nor test data in our laboratory to evaluate these claims by the manufacturer.

In relation with the anti-contamination performance, tracking resistivity is also very important particularly for outdoor insulators made of synthetic materials espetially when they are used under severely contaminated environment. According to our test results, tracking resistivity of silicone rubber was inferior to that of cycloaliphatic epoxy resin and polytetrafluorethylene (P.T.F.E). Refer to Technical Note TN-74012 attached.

At the present moment, NGK is forcussing our development efforts on cycloaliphatic epoxy reisn insulators and P.T.F.E. insulators though silicone rubber remains one of our objects of research and development.

FORSCHUNGS-
GEMEINSCHAFT FÜR
HOCHSPANNUNGS- UND HOCHSTROMTECHNIK E.V.

Highest leakage current impulse as criterion for the insulation performance of polluted insulators

M. P. Verma [+]

Pollution conditions are more or less inherent for outdoor insulation and lead to the development of conductivity on the surface of an insulator. This gives rise to thermal processes resulting into discharges which reduce the insulation strength. The insulation strength can be reduced to such an extent that a pollution flashover at the line-to-ground voltage becomes feasible. Fig. 1 shows a pollution flashover of an insulator.

To estimate the insulation strength of insulators under pollution in service, usually the limiting characteristic "Flashover voltage as a function of the degree of pollution" is determined in the laboratory (Fig. 2). The degree of pollution is expressed, according to the test procedure applied , in g/l for the case of salt fog test, in surface conductivity uS for the case of solid layer test procedure and in specific deposit mg/cm^2 for the japanese procedure. These values represent, however, the static degree of pollution (without test voltage). The dynamic value of the degree of pollution occuring during a pollution test can not be directly determined. The relation between the static and the dynamic values of the degree of pollution depends on the procedure used. Hence, the characteristics differ from each other correspondingly. These differences have led to many thoughts and discussions on the suitability and the correspondence of the existing test procedures with respect to the various natural pollution conditions.

[+] Dr.-Ing. M. P. Verma is Head of the Insulator Department of the Forschungsgemeinschaft für Hochspannungs- und Hochstromtechnik e. V., Mannheim-Rheinau.

FORSCHUNGS-
GEMEINSCHAFT FÜR
HOCHSPANNUNGS- UND HOCHSTROMTECHNIK E. V.
MANNHEIM-RHEINAU

FACHBEREICH 1
– Drehstromtechnik –

Composite Longrod Insulators for Transmission Lines

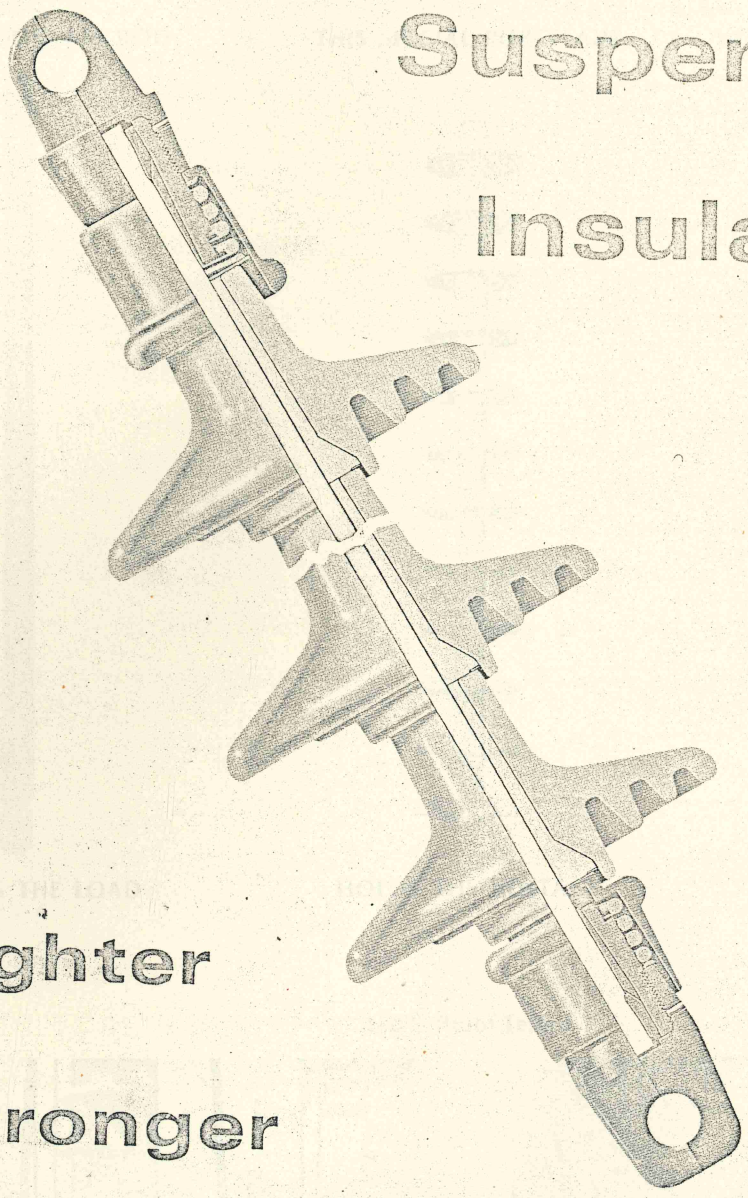
Dr. M. P. Verma
Forschungsgemeinschaft für Hochspannungs- und Hochstromtechnik e. V.
Mannheim, Germany

Paper for
IEEE WG, Winter Power Meeting, New York 1977

Introduction

A composite longrod insulator offers many advantages as compared with the conventional porcelain longrod and porcelain and glass cap-and-pin insulators /1/. The composite longrod insulator, however, also presents new problems leading finally to the question of life-time of insulators in service. A few types have been developed using different constructional details and synthetic materials covering a glass-fibre resin rod, the latter being in common to all types /2/. Before the question of regular use of these insulators in transmission lines is decided, the laboratory tests must be defined and specified. From the point of view of such an insulator, the tests should cover the materials used and also the final insulator with specific reference to its construction. With respect to the stresses experienced by the insulators in service, some of these can be very different depending on the climatic and environmental conditions of the site or the country of use. The following view points must therefore be kept in mind while dealing with the question of test specifications.

Unitary Suspension Insulator



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CATALOG 302-69

Survey of new insulation methods

Companies reveal their operating experiences with new plastic and fiberglass line insulators

By Merlin F. Wadsworth, Senior Transmission Engineer, Tampa Electric Co., Tampa, Fla.

◆ As the pressures continue to increase on the utilities to beautify or go underground with transmission lines, new techniques of insulation have been appearing on the market in recent years. Hopefully, these methods will successfully meet the criteria of being eye appealing while still maintaining the reliability of the more proven methods. This paper is a summary of the success or failure of some of the new methods as reported in a survey.

The information for this survey was compiled from answers to a questionnaire which was sent to all of the 24 members of the Southeastern Electric Exchange, Transmission and Large Substation Section. Several questions were asked dealing with the use of new methods of insulation at the transmission voltage levels. Twenty-three of the companies responded, and of these, 17 had used plastic or fiberglass insulation for transmission lines.

Experimental and standard

The installations by these companies were both on an experimental basis and as a standard of construction. The two major types of insulation reported on were the epoxy-type polymer insulator and the epoxy-fiberglass rod in series with porcelain or toughened glass insulators. One company reported an installation using the epoxy-type polymer in series with porcelain. The 17 companies that used these new methods of insulation reported on 32 different installations; of these 32, 16 were considered to have successful operating records and 16 had unsuccessful operating records.

No attempt is made to discuss the relative merits of each type of insulation nor is any inference made from the answers received on the questionnaire. The information is factually reported in a summary of the results in the following paragraphs.

Epoxy-type polymer

Out of the 12 installations of the epoxy-type polymer insulator, 11 had unsuccessful operating records. The one company which reported no trouble to date had 3 units installed in the horizontal deadend position. These units have been in service for 5 years. These 12 installations consisted of a total of 496 units, 420 of which were installed by one company. The other installations were in small quantities on an experimental basis only. These companies, all 10 of which reported problems with these units, have removed from service all of the units on their systems. The company which had 420 units installed, has removed all suspension units and retained 222 units in service in strain strings on which they had no problems. This is consistent with the problems which arose on all installations.

The majority of the units causing problems were installed in the vertical suspension position. The major problem was surface tracking. The tracking caused carbonization of the units which gradually increased to the point of flashover or puncture of the skirts on the unit. Eight of the 11 installations were credited with causing one or more outages.

Many of the units were installed in contaminated areas and the life of those which failed was dependent on the amount of contamination. The fact that the horizontal units performed better than those in suspension, seems to support the theory that insulators in horizontal strings perform better in contaminated areas than do those in vertical strings. The life ranged from several months to 6 years for those units which failed; the mean life approximated 2 years. The operating voltages of the installations were 69 kV, 115 kV, and 138 kV.

Epoxy-fiberglass rod

The other major category of plastic and fiberglass insulation reported on by the companies answering the survey was the epoxy-fiberglass rod in series with porcelain or toughened glass insulators. The voltage range of these installations was from 23 kV to 230 kV.

There were 20 different installations of this type of insulation; four of these had unsuccessful operating records and 15 were reported to be operating satisfactorily. One installation included in the table of unsuccessful operations was not having problems but was included in that table because the units had been removed from service and the reporting company did not plan to use this type of unit in the future.

The four installations having problems consisted of a total of 1454 units installed at voltages of 69 kV, 115 kV and 138 kV. The

(Continued on page 99)

CHARACTERISTICS OF FIBERGLASS AND POLYMER INSULATION

Edward S. Wheeler
Manager-Engineering
Insulator Products Dept.
General Electric Company
Baltimore, Maryland

A Paper Presented at the
Southeastern Electric Exchange
April, 1971 Meeting
Jung Hotel
New Orleans, Louisiana

A COMPARISON OF GENERAL ELECTRIC'S GEPOL INSULATOR AND A. B. CHANCE'S EPOXILATOR

INTRODUCTION

Following a 13 year development program on plastic insulators for outdoor use at high voltages, the General Electric Company introduced its 15 KV Gepol strain insulator in February 1967. It was the first commercially available plastic outdoor insulator in the world; more than 60,000 were ~~sold~~ shipped to about 400 utilities during the next 3-1/2 years. Subsequent to introduction there were two changes made, in 1968.

In mid-1970 the A. B. Chance Company announced the commercial availability of a 15 KV plastic strain insulator, which it named the Epoxilator. The outward appearance of the product is very similar to the first version of the 15 KV Gepol.

By late 1970 we were able to obtain published characteristics of the Epoxilator, as well as commercially purchased units for test. Our planned test program covered mechanical, electrical, analytical, and other physical characteristics, based upon the applicable standards for porcelain distribution insulators as well as properties we have found pertinent to plastic insulators.

PUBLISHED CHARACTERISTICS

The published characteristics for strain 15 KV Gepol insulators, Epoxilators, and code requirements are shown in Table I.

TABLE I

PUBLISHED CHARACTERISTICS

Property	Required for 15 KV System	General Electric GEPOL	A.B. Chance EPOXILATOR
Catalog Number		10P012	C654-0000
MEE, Lbs.		10,000	10,000
Test, Lbs.		5,000	5,000
Leakage, Distance, In.	12	14	--
60 H_z Flashover, Dry, KV	80	100	100
60 H_z Flashover, Wet, KV	45	75	75
Impulse Flashover, Positive, KV	130	150	140
Impulse Flashover, Negative, KV	155	175	180
60 H_z Positive, KV	115	150	--
RIV @ 15 KV, 1M H_z, ~~HV~~ Max.	100	50	--
Net Weight, lbs.		3-1/4	1-3/4

GEPOL Insulators:

New Levels of Performance, Electrically and Mechanically

F. C. Vose, Mgr.—Polymer Insulator Engineering Insulator Products Dept., Baltimore, Md.

GENERAL ELECTRIC

Rosenthal
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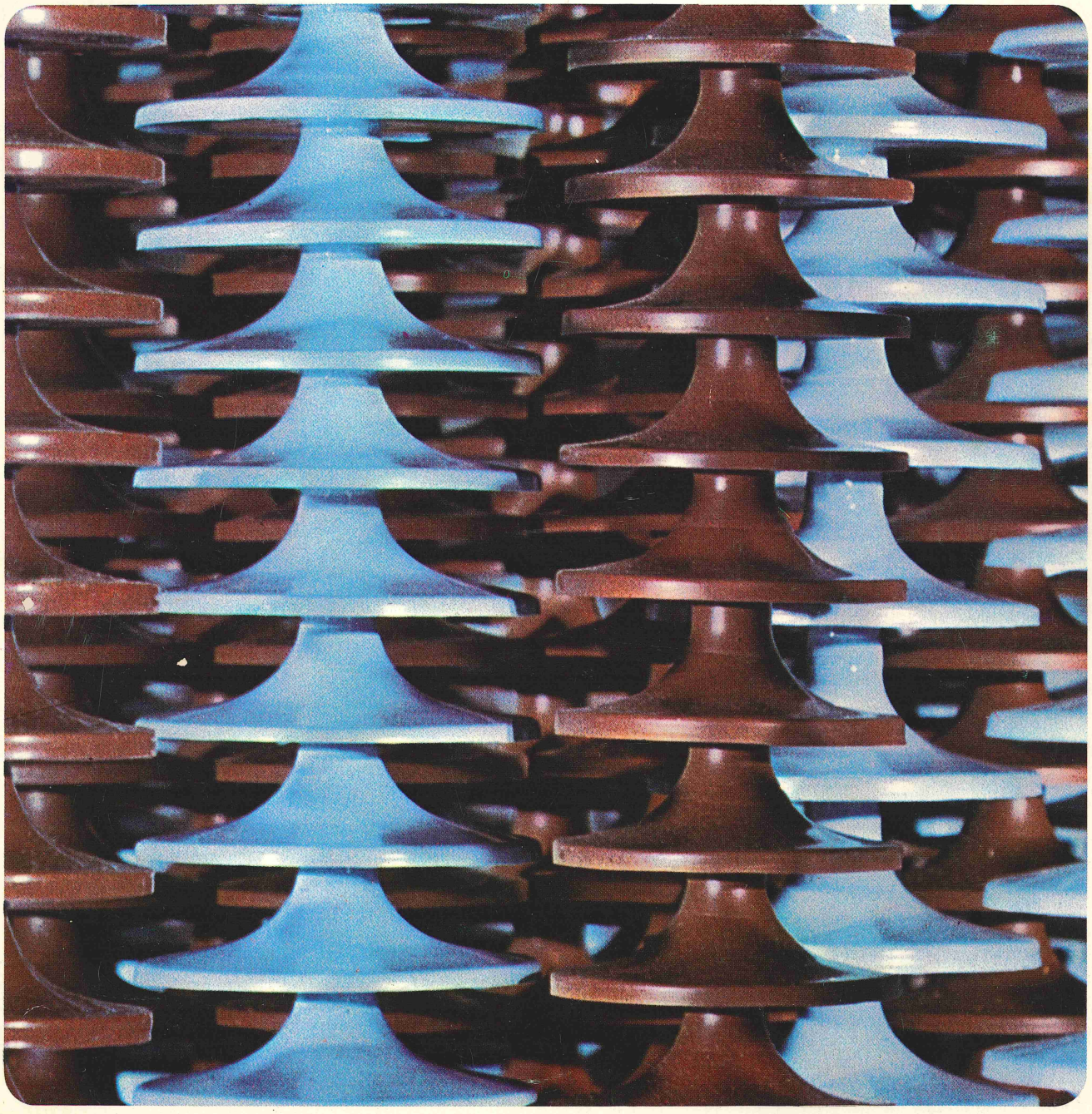
Technische
Keramik AG

Werksgruppe I Selb

RODURFLEX-
Kunststoffisolatoren für Freileitungen

RODURFLEX Plastics Insulators for Overhead Transmission Lines



A NON-PORCELAIN INSULATOR FOR TOMORROW'S CONSTRUCTION

Recent Materials Developments Make Lightweight Transmission Insulators Feasible

By

J. W. Elrod, EHV Application Engineer

H. G. Menzel, Marketing Manager

The Ohio Brass Company

INTRODUCTION – THE NEED

When the first 765-kv transmission lines were constructed the total weight of the insulator system became a significant factor in the mechanical design of the supporting structures. A quad-bundle tangent tower commonly used close to two tons of insulators. A deadend tower often used eight to nine tons of porcelain along with multi-string connecting hardware.

The next transmission level of approximately 1100-1200-kv can easily require six to eight tons of insulators and hardware per tangent tower. This dead weight required to support a multi-conductor UHV system is costly to install, expensive to support and introduces construction and maintenance problems.

Porcelain is now and has been for decades the accepted standard for high voltage insulation. The weight-to-strength ratio of porcelain was entirely satisfactory at lower transmission voltage levels. When the EHV level became a reality, a serious review was made of the multiple strings and the resulting strength-to-weight ratio requirements. This study clearly indicated that lighter weight and less complicated conductor support systems were not only desirable but were necessary for UHV construction.

Electrical insulation for overhead lines is provided by the surrounding air. The insulators maintain the necessary air flashover distance. The electrical function of an insulator is fulfilled if it does not become conducting under any conditions.

IREQ
Institut de recherche
de l'Hydro-Québec
1800, montée Sainte-Julie
Varennes, Québec, Canada

R Weller
Note "X" on next to last page.
This will be a very sticky area
for us.
BSR 10/9

October 1st, 1975.

Members
WG on Testing and Application of Non-Ceramic Insulators

Gentlemen:

I am enclosing a draft of the minutes of our recent meeting. It is important that any errors or omissions should be reported to me within 3 weeks of receipt of the draft.

Yours sincerely,

G Karady

DR. G. KARADY
Chairman of the WG

(encl)

RECEIVED
OCT 9 1975

NGK INSULATORS, LTD.

MAIN OFFICE
CABLE : NGKINSULATOR
NAGOYA
TELEX : NGK J59928

TOKYO OFFICE
NO. 20 MORI BLDG.
NISHISHINBASHI 2-CHOME
MINATOKU, TOKYO, JAPAN
CABLE : NGKINSULATOR
TOKYO
TELEX : NGKTOK J24250

MIZUHO, NAGOYA, JAPAN.

December 17, 1975

R. Wasler

Mr. B.E. Kingsbury
Vice President-Engineering
LOCKE INSULATORS, INC.
2525 Insulator Drive
Baltimore, Maryland 21230
U.S.A.

Dear Bruce:

Subject: Non-Ceramic Insulators W.G.

Thank you for your letter of October 13, 1975 which enclosed the minutes of the two IEEE Working Groups on Non-Ceramic Insulators and Contamination.

Non-ceramic (polymer) outdoor insulators have long been the subject of top importance in our research and development programs. As you are well aware, the work covers a very wide range of study and requires patient tests and trials of many years. We have not yet reached any conclusive results on materials, designs or test methods to be applied to the polymer outdoor insulators.

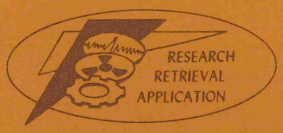
I will try my best to outline for you our thinking and works presently underway on these insulators.

1. We think that the prospect of these insulators exists in two different areas of application. The one is the application where a very high mechanical strength is required, because of its easiness to attain such a strength with comparatively light weight. The other relates to a special structural application, taking an advantage of its easiness to design long structural members of small diameter, light weight and high strength.

2. The long term reliability, life and cost are the decisive factors in evaluating these insulators. At present, no one expects that these insulators has a perpetual life a life equivalent to that of existing ceramic insulators. Also, the environmental and application conditions are far more influential in the life of these

POLYMERIC INSULATORS

MR. R. WELLER
LOCKE INSULATORS
2525 INSULATOR DRIVE
BALTIMORE, MD 21230



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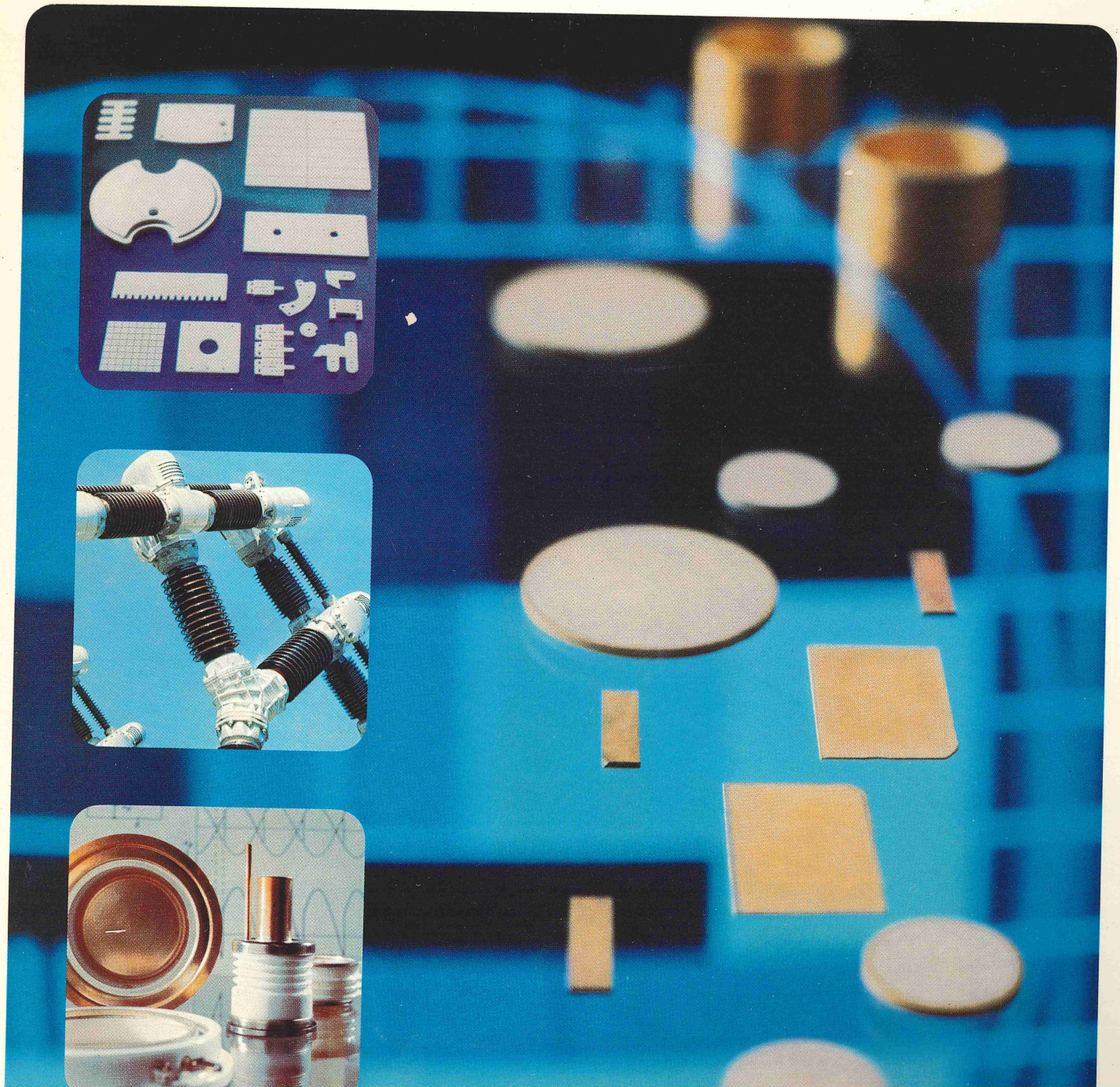
Rosenthal technik

Rosenthal Technik AG
Werksgruppe I



Dr.-Ing. Ewald A. Bauer
c/o. Rosenthal technik

rosenthal technik ag · 8672 selb · postfach 1508

To All Members of
WG on Non-Ceramic and
Composite Insulators for
Transmission Lines

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telefon (09287) 76-1
telex 06 43 533

sitz der gesellschaft: selb
registergericht hof
no. der eintragung: hrb 332
vorsitzender des aufsichtsrats:
philip rosenthal
vorstand:
heinz greiffenberger
oskar eckert

ihr zeichen	ihre nachricht	unser zeichen	direktwahl	datum
		M-Dr.Ba/Kb	09287/76- 370	29th June, 1976

Re : Mechanical Rating of Non-Ceramic Composite Longrod Insulators

Gentleman :

Enclosed please find a Paper "A Contribution Regarding Mechanical Rating of Non-Ceramic Composite Longrod Insulators".

This paper will be discussed on the occasion of the Portland Meeting on 19th July, 1976, as decided during our Winter Meeting.

Very truly yours,

En

OB-Hi*Lite

SUSPENSION INSULATORS

Hi*Lite published mechanical values inaugurate a new system of strength ratings stated as MAXIMUM DESIGN TENSION. The insulator may be worked at any mechanical load up to the maximum design tension shown below and on the nameplate.

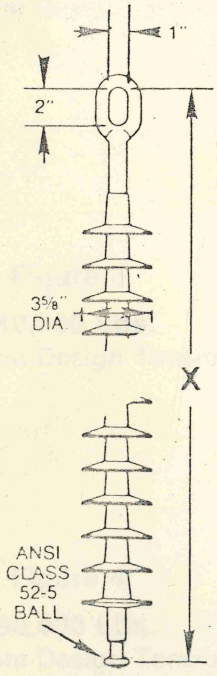


Figure 1
10,000 Lbs.
Maximum
Design
Tension

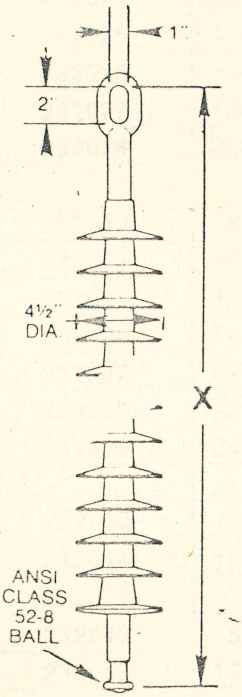


Figure 2
20,000 Lbs.
Maximum
Design
Tension

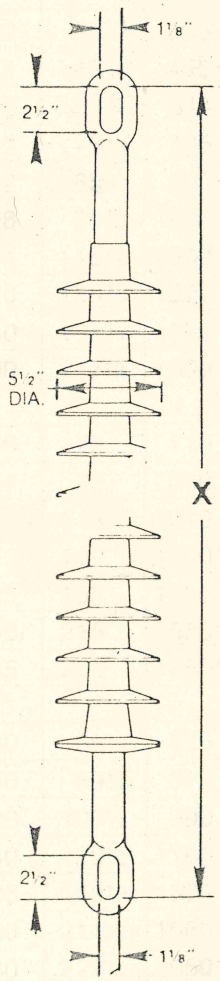


Figure 3
40,000 Lbs.
Maximum
Design
Tension

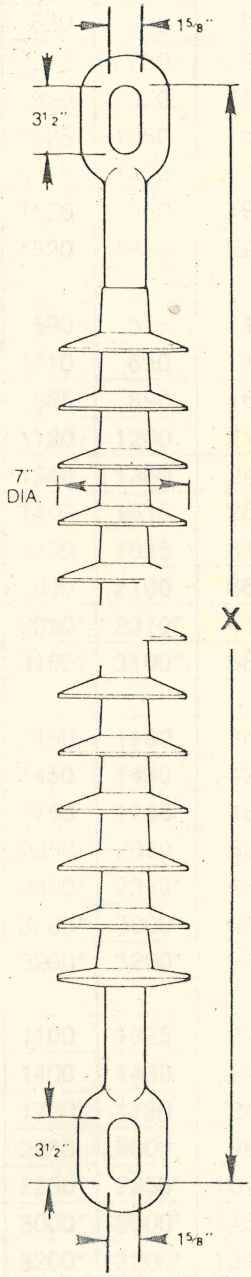


Figure 4
80,000 Lbs.
Maximum
Design
Tension

ROD DIA 5/8 7/8 1 1/4 1 3/4

NOTE: In Figures 1 and 2, an eye similar to top connection may be substituted for the ball when specified.

MAX DESIGN TENSION ≈ 1/3 UTS OF COMPLETE ASSEMBLY

can be attributed to the measuring-cable changes rather than to components. Solid dielectric cables were less affected by pulses than the composite air-plus-type cable.

Adams[110] presented data on the evaluation of insulated wires and cables under simulated space conditions (including the lunar environment). Reduction in weight and size is a primary target of this wire- and cable-development activity. In many applications, signal leads constitute the bulk of the hook-up wire used. AWG #32 copper wire is adequate, based on electrical requirements, but mechanical considerations dictate the use of AWG #24. New alloys of copper with zirconium and cadmium show promise of increasing the durability with little sacrifice in resistance. Another approach to the mechanical strength problem would be to fuse the wires into a monolithic structure as in present flat and contour cables. In general, TFE-insulated wire is best for all-around use in aerospace, but where outgassing or flammability are not problems, irradiated polyethylene could be used.

Klein and Scheiber[111] calculated the pressure differences for the insulation of an oil-filled pressure cable with fluted sheath, and the results were compared with those in a cable with a smooth sheath.

Erskine, Ricks, and Rudd[112] described the experience of the British Electricity Board with plastic-insulated cables for low-voltage distribution. Milne, Bates, and Gorham[113] reported on extensive trials the Electricity Board made on low- and medium-voltage, plastic-insulated-mains cables and on the limited trials with high-voltage, plastic-insulated-mains cables. Some of the methods used in the application of accessories were tried to simplify jointing procedure.

Stutz[114] discussed the replacement of cable-distribution-steel cabinets by reinforced-fiber-glass houses.

Neher[115] gave several families of curves, developed on a digital cumputer, which help determine the transient temperature rise of a buried-cable system.

V. Capacitors, Switchgear, and Insulators

Vail[116] reviewed the application requirements for dc filter and energy-storage capacitors.

Lengyel and Mitra[117] measured the electrical conductivity of thin, oil-impregnated, paper-insulated capacitors at high-electric fields as a function of temperature and voltage. They developed a theory which gave the approximate determination of the mobility of the charge carriers, assuming that the dominant part of the conduction in the oil takes place by means of ions.

Wehe and McMahon[118] described the development of a low-loss, polycarbonate-stripped-film capacitor. Its advantages are that it has low loss, approaching polystyrene, but is much smaller in size, and less sensitive to temperature, with an operating range between at least -78° and 125°C. The capacitors are "self-healing" and have long life under adverse conditions of temperature and voltage. An example of the size of one such hermetically sealed capacitor is .075 cubic inches in volume and 1/10 oz. in weight.

Johnston[119] related the experience of an explosion of flammable gases which occurred in August 1962 in a 161-kv oil circuit-breaker at the Oak Ridge gaseous-diffusion plant. He cites this as an example of flammable gases which might be produced by the decomposition of solid insulation and insulating oil as a result of faults in electrical equipment.

Kane and Colclaser[120] described a single-tank circuit-breaker, using SF_6 as the interrupting medium, and listed the test procedures used in life testing, voltage testing, and interruption testing.

T&D Industry Developments

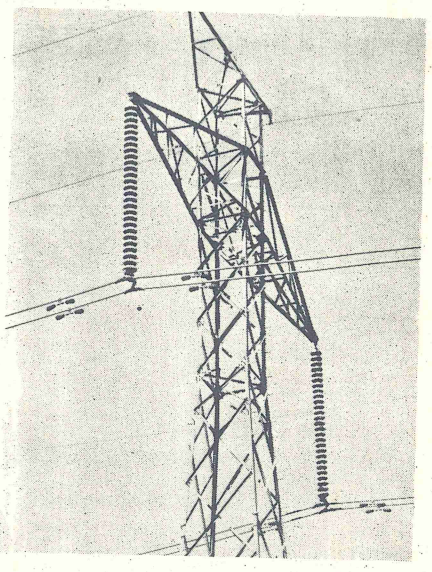
Test Proves Silicone Okay For HVDC Insulators

The Los Angeles Department of Water and Power has been testing a silicone compound on its HVDC transmission line. The tower for the test is about one mile from the Sylmar Converter Station and part of the 845-mile-long Pacific Intertie HVDC transmission line.

Although Sylmar is not considered an area of heavy contamination the insulators of the HVDC line collect particles and become dirty faster than the insulators on the comparable ac transmission lines. The particulate problem is aggravated by fog or nightly moisture condensation which makes the pollutant-soluble particles conductive and allows a leakage current over the insulator strings.

It is believed that some of the particulates are organic pollutants from vehicle exhausts on nearby freeways and that smog carries other pollutants from industrial facilities that are up to 60 miles away.

The Department tests were to determine the approximate length of time that the compound could be expected to prevent insulator flashover.



A 60-day insulator wash schedule is used on this tower in the 15-mile section of HVDC transmission line in Sylmar. Los Angeles Department of Water and Power selected the tower for long-term tests of silicone-coated insulator strings.

Dow Corning 3099 high voltage insulator compound was hand-applied in a nominal ⅛- to ¼-inch thickness on glazed porcelain suspension insulators in each of two strings.

After a 3-year test period, the high voltage silicone insulator compound had successfully protected the HVDC insulators from flashover. The compound was still hydrophobic, i.e., water would still bead up on its surface, but the compound had developed on the top side of the insulators a firm surface layer which no longer encapsulated atmospheric particles.

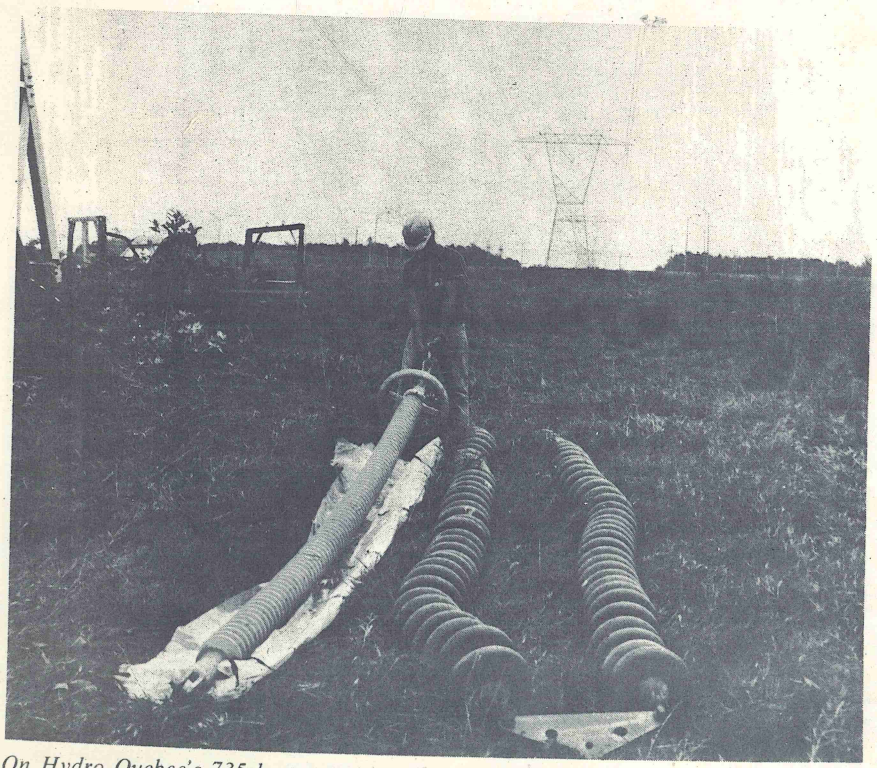
A major factor still to be determined is the difference in cost between washing the insulator strings every 60 days and the cost of applying the silicone compound to each of the strings.

Synthetic Insulators Used on 735-kv Line

Hydro-Quebec recently installed 240 synthetic insulators on 40 of the towers on the 735-kv transmission line between Laurentides and Levis substations, near Quebec City.

Using these new insulators on a transmission line exposed to severe weather marks the final phase of a test program undertaken in 1973. In the coming year, the utility expects to verify advantages of the new insulators ascertained in the laboratory.

The synthetic insulator is made of a fiber-glass rod encased in polymer to form a single unit. The synthetic insulators are said to weigh less than porcelain insulators and possess superior mechanical and electrical characteristics. For example, the equivalent synthetic insulation for two strings of conventional insulators weighing 548 kilograms is a single unit weighing only 32 kilograms. The new insulators also provide equal mechanical strength and cost less. A single unit of synthetic insulators has a diameter of only 13 centimeters, compared with 30 centimeters for each string of insulators.



On Hydro-Quebec's 735-kv transmission lines a single element synthetic insulator weighing only 32 kilograms may replace two-string porcelain insulators (right) weighing 548 kilograms.

April 1, 1971

CC: Manager-Manufacturing
Manager-Quality Control
Manager-Planning

Dear Sirs:

In reference to the ultimate goal of improving the operation and output of the GB-4 glaze machine, we have checked the glaze thickness of fifty Magnavalves -- twenty-five pieces picked at random from two cars dated March 15, 1971 and March 22, 1971 respectively. Four areas on each piece were checked using our newly acquired Hand Optical Reticle Comparitor. From the data generated, a computer program was written. The results of this program indicate that the GB-4 machine is capable of maintaining a glaze thickness within statistical limits. Of the four areas checked, only one failed to stay within statistical limits.

Now that we have tentatively proven the capability of the machine, the one area that shifted makes it apparent that there are some functions requiring more study before MSNs covering corrective action by the operator can be written. The data indicates that one or more of the glaze guns covering the top area of the Magnavalve either physically shifted in direction, or the rate of flow of glaze in these same guns changed. Insofar as the gun fixtures are concerned, I recommend that adjustments in elevation and transverse motion be made, to be fixed in direction after optimum position is determined. A number of things could cause the rate of flow of glaze to change, such as:

1. Gun stopped up by
    a. particles of hard glaze
    b. pieces of foreign material

April 1, 1971

CC: Manager-Manufacturing
Manager-Quality Control
Manager-Planning

Dear Sirs:

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1. Gun stopped up by
   a. particles of hard glaze
   b. pieces of foreign material

Lightning - Theory

Transactions Paper

(Reviewed and Accepted for Publication)

THE LIGHTNING STROKE - II

C. F. Wagner
Fellow AIEE

A. R. Hileman
Member AIEE

Both of:
Westinghouse Electric Corp.
East Pittsburgh, Pa.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE South East-South Central District Meeting, New Orleans, La., April 5-7, 1961. Manuscript submitted January 9, 1961; made available for printing March 3, 1961.

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Discussion in Duplicate Due April 21, 1961.

DF-53849

FN-460-F (6-47)

DATA FOLDER No. 53849

Subject STEEP FRONT IM PULSE TESTS WITH SERIES INDUCTANCE IN PLACE OF SERIES RESISTANCE

Issued by HIGH VOLTAGE ENGR. LAB. PITTSFIELD WORKS **Date** FEB. 7, 1949

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Transactions Paper

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DISCUSSION IN QUADRUPLICATE DUE February 13, 1970.

TRANSIENT IMPEDANCE OF HIGH VOLTAGE IMPULSE GENERATING SYSTEMS

F. C. Creed
Senior Member IEEE

M. M. C. Collins
Member IEEE

Both of:
National Research Council of Canada
Radio & Electrical Engineering Div.
Ottawa, Ontario, Canada.

A paper recommended by the IEEE Power System Instrumentation and Measurements Committee of the IEEE Power Group for presentation at the IEEE Winter Power Meeting, New York, N.Y., January 25-30, 1970. Manuscript submitted September 12, 1969; made available for printing November 3, 1969.

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Paper No.
70 TP 27 - PWR

Transactions Paper

(Reviewed and Accepted for Publication)

Impulse Measurement

MEASUREMENTS OF STEEP-FRONT IMPULSE WAVES WITH AN ISOLATED SCREEN ROOM INSTALLATION

C. J. Miller, Jr.
Fellow AIEE

J. F. Wittibschlager
Associate Member AIEE

Both of:
The Ohio Brass Co.
Barberton, Ohio

A paper recommended by the AIEE Special Instruments and Auxiliary Apparatus Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., February 2-7, 1958. Manuscript submitted October 15, 1957; made available for printing October 29, 1957.

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58-18

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AIEE
Technical Paper
54-53

November 1953
Litho in USA

Discussion for publication

must be postmarked on or before

February 3, 1954.

Mr. Vose
" Kingsbury

VOLTAGE DIVIDER FOR MEASURING IMPULSE VOLTAGES ON TRANSMISSION LINES

S. B. Griscom
Fellow AIEE

B. L. Lloyd
Associate Member AIEE

A. R. Hileman
Associate Member AIEE

All of:
Westinghouse Electric Corp.
East Pittsburgh, Pa.

Advance Copy
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Transactions Paper

(Reviewed and Accepted for Publication)

DISCUSSION IN QUADRUPLICATE DUE February 19, 1971.

FIRING AND VOLTAGE SHAPE OF MULTISTAGE IMPULSE GENERATORS

F. W. Heilbronner
Hochspannungsinstitut, Technical University
Munich, Germany

A paper recommended by the IEEE Power System Instrumentation & Measurements Committee of the IEEE Power Engineering Society for presentation at the IEEE Winter Power Meeting, New York, N.Y., January 31-February 5, 1971. Manuscript submitted September 15, 1970; made available for printing December 8, 1970.

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Paper No.
71 TP 121 - PWR

Transactions Paper

(Reviewed and Accepted for Publication)

DISCUSSION IN QUADRUPLICATE DUE February 19, 1971.

SHAPING CIRCUITS FOR HIGH VOLTAGE IMPULSES

F. C. Creed
Senior Member IEEE

M. M. C. Collins
Member IEEE

Both of:
National Research Council of Canada
Radio & Electrical Engineering Division
Ottawa, Ont., Canada.

A paper recommended by the IEEE Power System Instrumentation & Measurements Committee of the IEEE Power Engineering Society for presentation at the IEEE Winter Power Meeting, New York, N.Y., January 31-February 5, 1971. Manuscript submitted September 16, 1970; made available for printing November 25, 1970.

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Transactions Paper

(Reviewed and Accepted for Publication)

DISCUSSION IN QUADRUPLICATE DUE February 19, 1971.

BREAKDOWN CHARACTERISTICS OF A SPHERE-PLATE TRIGGERED AIR SPARK-GAP

B. C. Papadias
Member IEEE
Athens National Technical University
Athens, Greece

A paper recommended by the IEEE Power System Instrumentation & Measurements Committee of the IEEE Power Engineering Society for presentation at the IEEE Winter Power Meeting, New York, N.Y., January 31-February 5, 1971. Manuscript submitted September 16, 1970; made available for printing December 11, 1970.

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Paper No.
71 TP 125 - PWR

INSULATOR DEPARTMENT

GENERAL ELECTRIC COMPANY

Baltimore, Maryland

Technical Report No. 645-DR
May 20, 1958.

SUBJECT

Suspension and Switch Insulator Electrical Data And Miscellaneous Electrical Information

This report contains:

List of Tables
List of Figures
Appendices
24 Typewritten Pages.
34 Curves

Signed B E Kingsbury

Approved Fred C Rose

A CONSIDERATION OF THE RADIO-FREQUENCY VOLTAGES ENCOUNTERED BY THE INSULATING MATERIAL OF BROADCAST TOWER ANTENNAS

BY

GEORGE H. BROWN

Reprinted from Proceedings of the I.R.E.
Vol. 27, No. 9, September, 1939

PRINTED IN THE U.S.A.

To R. L. McCoy
Courtesy
A H Burnham
10/

Mechanics

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ELECTRONICS DEPARTMENT

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR	SUBJECT CLASSIFICATION	NO.
M. E. Gurtin	Shock and Vibration	R57EML38
		DATE 31 Dec. 1957

TITLE

Procedure for Running Shock and Vibration Tests

ABSTRACT

This report outlines general procedures which will assist the environmental engineer in running vibration and shock tests. A study is made of proper jig design, and proper instrumentation and calibration procedures.

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For list of contents—drawings, photos, etc. and for distribution see next page (AO-147-A).

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DIVISIONS LMEE Department LOCATION French Road, Utica, New York

FN-610-1F-E (11-50)

76909

TECHNICAL INFORMATION

SHORT-CIRCUIT CURRENTS IN LOW AND MEDIUM VOLTAGE AC POWER SYSTEMS

ENGINEERING APPLICATION DATA

INDUSTRIAL ENGINEERING DIVISIONS

GENERAL ELECTRIC

MECHANICAL STRESSES IN BUSBAR SUPPORTS DURING SHORT CIRCUITS

by

O. R. Schurig

M. F. Sayre

Presented at Midwinter Convention of the AIEE - New York, NY
February 9-12, 1925

MECHANICAL STRESSES IN BUSBAR SUPPORTS DURING SHORT CIRCUITS

By O. R. SCHURIG and M. F. SAYRE

1925

NATURAL FREQUENCIES OF INSULATOR MOUNTED BUS BARS

H. PORITSKY

H.D. SNIVELY

1939

MECHANICAL STRESSES IN BUSBAR SUPPORTS DURING SHORT CIRCUITS

O.R. SCHURIG and M.F. SAYRE

1925

EQUIVALENT ELECTRICAL AND MECHANICAL DOUBLE FREQUENCY SYSTEMS WITH SPECIAL APPLICATION TO SHORT CIRCUIT STRESSES IN SIMPLE DUE STRUCTURES

by

E. R. Boehne
W. S. Weil, Jr.
General Electric Co - Philadelphia, PA

1925

GENERAL ELECTRIC

BEHAVIOR OF HIGH VOLTAGE BUSSES AND INSULATORS DURING SHORT CIRCUITS

R. M. Milton

Fred Chambers

1954

includes: TVA Paper & discussion

PRELIMINARY REPORT ON CALCULATION OF LATERAL STRESSES IN HIGH TENSION BUS INSULATORS DURING SHORT CIRCUITS

GENERAL ELECTRIC

APPARATUS

FOR

PRELIMINARY REPORT ON

CALCULATION OF LATERAL STRESSES

IN HIGH TENSION BUS INSULATORS DURING

SHORT CIRCUITS

Information Prepared By: Electric Utility Engineering
C. G. Adams
R. A. Schmidt
J. I. Whittlesey

Date: March 4, 1955

APPARATUS DEPARTMENT
GENERAL ELECTRIC
COMPANY

Form 13861 10m 3-17-50 new

Conference Paper

SAG AND TENSION CALCULATIONS BY THE NOMOGRAPHIC METHOD

Robert H. Sarikas
Member AIEE
Illinois Power Company
Decatur, Ill.

A paper recommended by the AIEE Transmission and Distribution Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 28-February 2, 1962. Manuscript submitted October 30, 1961; made available for printing December 20, 1961.

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Paper No. **CP**
62-107

Transactions Paper

(Reviewed and Accepted for Publication)

PHASE-TO-PHASE SWITCHING SURGES ON LINE ENERGIZATION

I. B. Johnson
Fellow AIEE
General Electric Company
Schenectady, N.Y.

R. F. Silva
Associate Member AIEE
University of Connecticut
Storrs, Conn.

D. D. Wilson
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Schenectady, N.Y.

R. F. Silva was formerly with the General Electric Company.

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Paper No.
62-108

Discussion in Duplicate Due February 16, 1962.

Transactions Paper

(Reviewed and Accepted for Publication)

SWITCHING SURGE AND DYNAMIC VOLTAGE STUDY OF ARIZONA PUBLIC SERVICE COMPANY 345 KV PROPOSED TRANSMISSION SYSTEM UTILIZING MINIATURE ANALYZER TECHNIQUES

W. H. Croft
Member AIEE
Arizona Pub. Service Co.
Phoenix, Ariz.

R. H. Hartley
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Phoenix, Ariz.

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Schenectady, N. Y.

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NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
NEMA

STANDARDS PUBLICATION

HIGH-VOLTAGE INSULATORS

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION 155 EAST 44TH STREET, NEW YORK, N. Y. 10017

ENGINEERING LABORATORY

Plastics

EPOXY RESIN DEVELOPMENTS AND APPLICATIONS
IN PETERBOROUGH WORKS

BY

R.W. PARNELL

DQF58AD-7

28 FEBRUARY 1958

CANADIAN GENERAL ELECTRIC COMPANY LIMITED

APPARATUS DEPARTMENT

APP 3017

The A, B, C of QUALITY CONTROL

By J. M. JURAN

ASSISTANT TO THE ADMINISTRATOR, FOREIGN ECONOMIC ADMINISTRATION, WASHINGTON, D. C. MEMBER A.S.M.E.

MANUFACTURE begins with a specification of the product to be made. This specification is a piece of industrial legislation, drafted by the design engineers, who are the legislators of the industrial world. The making of products to conform to this legislation is the joint responsibility of the manufacturing engineers and factory personnel who collectively constitute the executive branch of the industrial world. The inspectors perform the judicial function of the industrial world. They compare the product with the specifications to see whether there is conformance. The cycle is completed when the inspection data are used by the design engineers for design modification.

While these three functions of specification, operation, and inspection are clearly separable, they must be co-ordinated if the conformance of product with specification is to be achieved at minimum cost. Conformance of product with specification can be achieved even when functional lines are too tightly drawn. However, overfunctionalization increases the cost of securing conformance. Only through co-ordination of these three functions can minimum cost of conformance be achieved.

THE INSPECTION ACT AND THE PURPOSES OF INSPECTION

The management tool which we have come to know as "quality control" can make an important contribution toward achieving this co-ordination between specification, operation, and inspection. But what do we mean by inspection? Actually there are four different purposes which can be served by what we call "inspection." Yet the steps followed by the inspector "at the bench" are basically unvarying, no matter what the purpose of the inspection he performs. In all cases, the inspector functions as follows: (*a*) Interprets the specification; (*b*) measures the product; (*c*) compares the product with the specification; (*d*) judges conformance; (*e*) disposes of the product; (*f*) records the resultant data. This series of steps we shall call the "inspection act."

While the inspection act is fundamental to all inspection, the purposes served by inspection can be classified into four basic groups:

Acceptance Sampling. This is an inspection on a sampling basis to distinguish acceptable lots of product from nonacceptable lots. Acceptance sampling has for its primary purpose the grading of lots of product. The data obtained are incidental, but can often be put to effective use.

Control Sampling. This is an inspection on a sampling basis, for the purpose of securing data for exercising control. Sampling to regulate the manufacturing process, to rate quality of product, to rate quality performance of operators, or to measure accuracy of inspectors are all instances of control sampling. Here the purpose of the inspection act is to obtain data which can form the basis of management control. Any grading or sorting of product is incidental.

Operational Sorting. This is a manufacturing operation which has the outward appearance of a detail inspection. The purpose is to sort good pieces from bad. The necessity for the sorting arises from the fact that the manufacturing process delivers defective pieces to an extent too great to permit acceptance on a sampling basis. The question of good or poor performance on the part of the operators is not present. For example, the final performance test of a transformer or a generator is an operational sorting. The various operators cannot know whether their collective efforts have resulted in a finished product which meets the tests.

Corrective Sorting. This is also a sorting of the product but arises from the fact that through failure on the part of the operators the product contains defects to an extent too great for acceptance on a sampling basis. For example, a detail inspection for adjustment is necessary only if the operators fail to adjust properly. In such cases the operators are equipped with a full complement of gages, and so forth. They must themselves test to see whether the product is adjusted, for without such test they do not know when to stop adjusting.

Corrective sorting is, for the most part, a "needless" loss. In many shops it is confused with operational sorting and permitted to go on year after year. Furthermore, existence of such sorting is a symptom of an even greater loss—the loss of material plus the time to make good the defectives.

HOMOGENEITY THROUGH MIXTURE AND THROUGH COMMON ORIGIN

In mass production the product can be considered as a stream emerging from the creating source. This stream may be a true stream of liquid or gas, or it may be a continuous solid like an extrusion, or it may be a series of discrete pieces. No matter which of these forms the product takes, there are impinging upon each element of the product, at the time of its creation, the numerous variables in the process. The final characteristics of the product are the result of the combined effect of these variables.

In many cases there is close relation between inspection of product in fluid or continuous form and inspection of product in discrete pieces. For example, measurement of a coil of cold-heading wire for diameter presents much the same problem as the subsequent measurement, for diameter, of the screw blanks cut from that coil of wire. The measurement, for thickness, of a load of spring-steel sheets is a problem much like that of measurement, for thickness, of the steel springs punched from those sheets. The coil of wire and the sheet of steel are each, in a sense, a great many pieces all connected together, and requiring an operation to disjoint them into discrete pieces.

It is valid, even when the product is a continuous or disjointed solid, to consider all product as consisting of a stream flowing from the creating origin. The validity of this concept is in the existence of a reservoir or process which can pour out product. The reservoir pouring out the product may contain much of the product during the pouring process, as in the case of a tank car of gasoline, or the reservoir may be empty, but

[1] Derived from "Control Sampling," chapter 6 of "Management of Inspection and Quality Control," by J. M. Juran, to be published by Harper & Bros., New York, N. Y., in the fall of 1944. For other chapters from this book see "Management Problems of Measurement in the Inspection Function," *Advanced Management*, July-Sept., 1943, pp. 86–91, 103; and "Management Problems in Judging Quality Conformance in the Inspection Function," MECHANICAL ENGINEERING, vol. 65, 1943, pp. 805–808.

Contributed by the Management Division and presented at the Semi-Annual Meeting, Pittsburgh, Pa., June 19–22, 1944, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

AIEE
Miscellaneous Paper
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POSTWAR PLANNING FOR HIGH VOLTAGE TRANSMISSION IN NORTHERN CALIFORNIA

W. R. Johnson
Member AIEE
Pacific Gas and Electric Company
San Francisco, Calif.

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AIEE
Technical Paper
51-11

November 1950
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Bob McCoy

THE 300/315 KV EXTRA HIGH VOLTAGE TRANSMISSION SYSTEM OF THE AMERICAN GAS AND ELECTRIC COMPANY

Philip Sporn
Fellow AIEE

E. L. Peterson
Member AIEE

I. W. Gross
Fellow AIEE

H. P. St. Clair
Fellow AIEE

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American Gas and Electric Service Corporation
New York, N. Y.

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B.E.K.

LOCKE INSULATOR CORPORATION
Baltimore Maryland

Technical Report No. 501

Subject

The Analysis of Internal Mechanical
Stresses By An Electrical Analogy

This report contains:

9 Typewritten Pages

Signed H A Fong Approved W E Hiss

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Lightning - Theory

Conference Paper

EFFECT OF PREDISCHARGE CURRENTS UPON LINE PERFORMANCE

C. F. Wagner
Fellow AIEE

A. R. Hileman
Member AIEE

Both of:
Westinghouse Electric Corp.
East Pittsburgh, Pa.

Submitted in abstract or outline form only to the AIEE Transmission and Distribution Committee for presentation at the AIEE Summer General Meeting, Denver, Colo., June 17-22, 1962. Manuscript submitted April 11, 1962; made available for printing April 12, 1962.

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Paper No. **CP**

62-1181

Lightning - Theory

Conference Paper

RELATION BETWEEN STROKE CURRENT AND VELOCITY OF THE RETURN STROKE

C. F. Wagner
Fellow AIEE
Westinghouse Electric Corp.
East Pittsburgh, Pa.

A paper recommended by the AIEE Transmission and Distribution Committee for presentation at the AIEE Summer General Meeting, Denver, Colo., June 17-22, 1962. Manuscript submitted March 21, 1962; made available for printing April 25, 1962.

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Paper No. CP
62-1094

Lightning Theory

Transactions Paper

(Reviewed and Accepted for Publication)

MONTE CARLO COMPUTER CALCULATION OF TRANSMISSION LINE LIGHTNING PERFORMANCE

J. G. Anderson
Member AIEE
General Electric Company
Pittsfield, Mass.

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Transactions Paper

(Reviewed and Accepted for Publication)

A NEW APPROACH TO THE CALCULATION OF THE LIGHTNING PERFORMANCE OF TRANSMISSION LINES -- PART III. A SIMPLIFIED METHOD - STROKE TO TOWER

C. F. Wagner
Fellow AIEE

A. R. Hileman
Member AIEE

Both of:
Westinghouse Electric Corp.
East Pittsburgh, Pa.

RECEIVED
APR 14 1960
H. A. FREY

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE North Eastern District Meeting, Providence, R. I., May 2-4, 1960. Manuscript submitted January 6, 1960; made available for printing March 21, 1960.

Price: $ .50 To Members
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Paper No.

60-658

Discussion in Duplicate Due May 18, 1960.

Transactions Paper

(Reviewed and Accepted for Publication)

A NEW APPROACH TO THE CALCULATION OF THE LIGHTNING PERFORMANCE OF TRANSMISSION LINES - II

C. F. Wagner
Fellow AIEE

A. R. Hileman
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Both of:
Westinghouse Electric Corp.
East Pittsburgh, Pa.

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Middle Eastern District Meeting, Baltimore, Md., May 19-21, 1959. Manuscript submitted February 19, 1959; made available for printing March 27, 1959.

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59-644

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Transactions Paper

(Reviewed and Accepted for Publication)

DETERMINATION OF THE WAVE FRONT OF LIGHTNING STROKE CURRENTS FROM FIELD MEASUREMENTS

C. F. Wagner
Fellow AIEE
Westinghouse Electric Corp.
East Pittsburgh, Pa.

RECEIVED
APR 14 1960
H. A. EREY

A paper recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE North Eastern District Meeting, Providence, R. I., May 2-4, 1960. Manuscript submitted February 1, 1960; made available for printing March 21, 1960.

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Paper No.
60-657

Discussion in Duplicate Due May 18, 1960.

AIEE CONFERENCE PAPER NO. 59-341

DETERMINATION OF LIGHTNING RESPONSE OF TRANSMISSION LINES BY MEANS OF GEOMETRICAL MODELS

F.A. Fisher
Associate Member - AIEE

J.G. Anderson
Member - AIEE

J.H. Hagenguth
Fellow - AIEE

January 21, 1959

Technical Report LK-857

VISUAL CORONA AND RIV TESTS

on

(6) 345 KV LINE ASSEMBLIES

Customer: Consumers Power (Mr. D. Bennett-Inspector)

Vendor: Bethea Co., Inc.

Author:

C. H. Matthews
Manager-High Voltage & Mechanical
Laboratory

Approved:

E. S. Wheeler 12/20/67
E. S. Wheeler
Manager - Engineering

General Electric Company
Insulator Department
November 20, 1967

RECORD OF TESTS NO. 24242

THERMAL ENDURANCE TESTS ON SUSPENSION INSULATORS FOR CONEMAUGH PROJECT

A. L. Libby
Product Engineer

R. Weller
Product Engineer

C. Bowen
Baltimore Gas & Electric Co.

R. H. Lester, Manager
Ceramic Insulator Engineering

INSULATOR DEPARTMENT GENERAL ELECTRIC COMPANY BALTIMORE, MARYLAND
December 2, 1968

TECHNICAL REPORT LK-974-DR

EVALUATION OF 15 KV SWITCH AND BUS INSULATORS

Author:

J. M. Jesatko
Product Engineer

Approved:

R. H. Lester, Manager
Ceramic Insulator Engineering

Distribution:

ES Wheeler
AL Libby
R Weller
CD Croskey

INSULATOR PRODUCTS DEPARTMENT GENERAL ELECTRIC COMPANY BALTIMORE, MARYLAND
April 1, 1971

File

Letter attached

GENERAL ELECTRIC COMPANY

INSULATOR DEPARTMENT

Technical Report No. LK-664-DR

March 8, 1960

SUBJECT

Investigation of Catalog No. 29153 Insulators from Alabama Power Company

R. Weller

This Report Contains:

5 typewritten pages
4 tables
4 figures and photographs

Baltimore, Maryland

Signed Renouf Weller

Approved Fred C. Voss

TECHNICAL REPORT LK-970-DR
Supplement #1

DIELECTRIC STRENGTH CHARACTERISTICS OF CERAMIC COMPOSITIONS

Author:

J. M. Desatko
Product Engineer

Approved:

R. H. Lester, Manager
Ceramic Insulator Engineering

Distribution:

ES Wheeler
TH Dressel
PB Horton
BE Kingsbury
RH Lester
AL Libby
R Weller

INSULATOR PRODUCTS DEPARTMENT GENERAL ELECTRIC COMPANY BALTIMORE, MARYLAND
September 27, 1971

File
Test Reports

INSULATOR DEPARTMENT
GENERAL ELECTRIC COMPANY
Baltimore Maryland

TECHNICAL REPORT NO. LK-840

60 CYCLE ARCOVER CURRENT TESTS ON INSULATORS

15 KV GEPOL - Cat. No. 10P012

15 KV Suspension (Porcelain)
Cat. No. 16583-G11
(Two in Series)

Aurthor:

C. H. Matthews

C. H. Matthews, Manager-High
Voltage & Mechanical Lab.

Approved:

E. S. Wheeler

E. S. Wheeler, Manager-Engineering

May 25, 1967

NGK TRIP REPORT

February 21 through 25, 1972

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J. Kelenfy
B. E. Kingsbury

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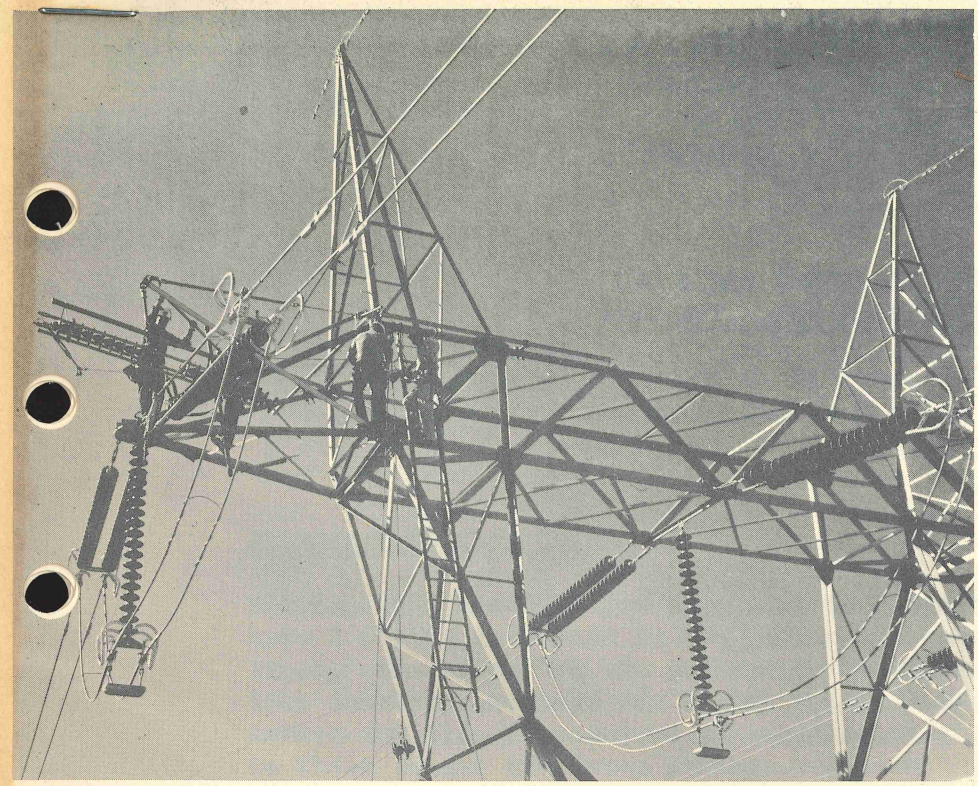
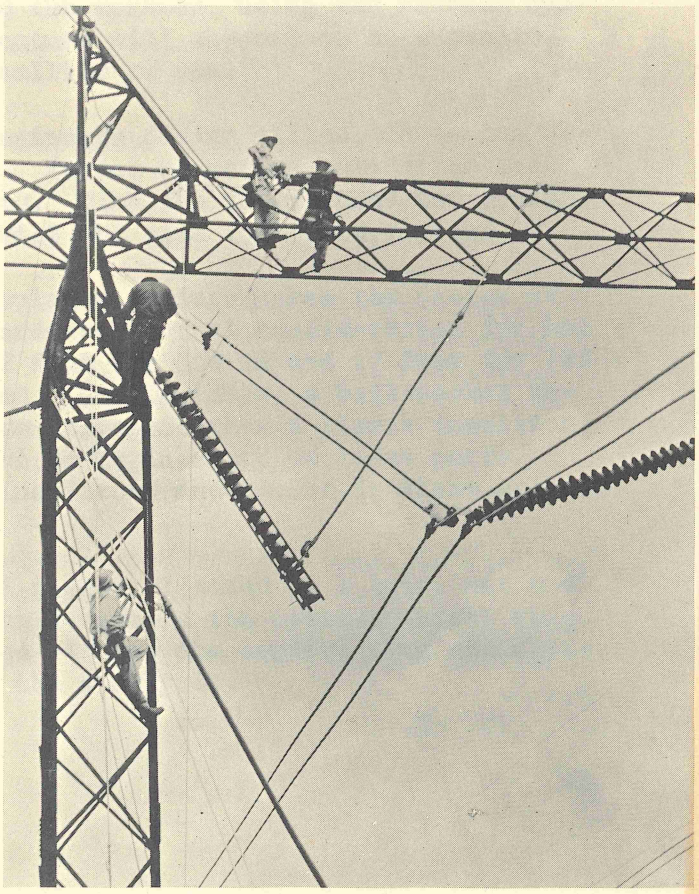


by

O. G. ANDERSON
A. B. CHANCE COMPANY
Centralia, Missouri

EHV Lines Engineered for Safe-Efficient Maintenance



PEA MEETING

Skytop

Pocono Mts., Pennsylvania

MAY 19, 1967

TRASER
Laser Current Devices For HV & EHV Systems

by

R. F. SWOISH

Manager - Product Application
Circuit Breakers

Allis-Chalmers Boston Plant
Boston, Massachusetts

LITHO IN USA A-C

Presented before

PENNSYLVANIA ELECTRIC ASSOCIATION
ELECTRICAL EQUIPMENT COMMITTEE
October 14, 1965
York, Pennsylvania

Not released for publication except by permission of Allis-Chalmers, Technical Press Bureau, Milwaukee, Wis.

ALLIS-CHALMERS

45 P 2287

THE ELECTRICAL PERFORMANCE OF CERAMIC DIELECTRICS

AT ELEVATED TEMPERATURES

- o O o -

It is well known that the electrical resistance of most of the commonly used insulating materials diminishes with increasing temperature. The actual performance of ceramic insulating materials at temperatures above the normal atmospheric level, and the factors affecting the ultimate breakdown at these temperatures, has not been the subject of much investigation. Recent requirements for insulators to operate at high temperatures and high voltages have indicated the need for such information.

Apparatus and Method.

It was necessary to provide a suitable test chamber in which the specimens could be mounted and held at any desired temperature while voltage was applied. Accordingly, a thermally insulated box or furnace was built. The electrical heating elements in the back of the box were separated from the test chamber by a one inch thick thermally insulating partition in order to prevent direct heating of the specimens by radiant heat. The heated air was circulated by means of a fan thru ports at each end of the test chamber. The fan also served to maintain air turbulence in the test chamber and thus prevent stratification. Temperature measurements were by commercial gas thermometer and automatic controls were provided for holding any desired temperature between minus 100 degrees Fahrenheit and 1000 degrees Fahrenheit. With this arrangement temperatures could be held within five degrees Fahrenheit of the desired level. Provision was also made for removing the heating elements from the back of the box and substituting racks of dry ice in order to obtain low temperatures.

Most of the tests were made with d-c voltage in order to eliminate the difficulty of separating conduction currents from charging currents. The voltage source was a full wave high voltage kenetron rectifier with suitable capacitors for the elimination of the sixty cycle pulse.

The d-c voltages were measured by means of a suitable known resistance connected in series with a microanmeter.

Most of the test specimens were prepared in the form of plates of various thicknesses. Some specimens were made from standard suspension insulator shells using the head section, ground down to the desired thickness, as the test area.

Electrodes of circular shapes were applied to the opposite sides of each test specimen. Guard rings were also provided to eliminate the effect of surface leakage and corona, and to preserve a more nearly uniform field thru the test zone. The electrodes and guard rings were of silver ceramically bonded to the surface of the dielectric to avoid entrapped air between the dielectric and its electrode.

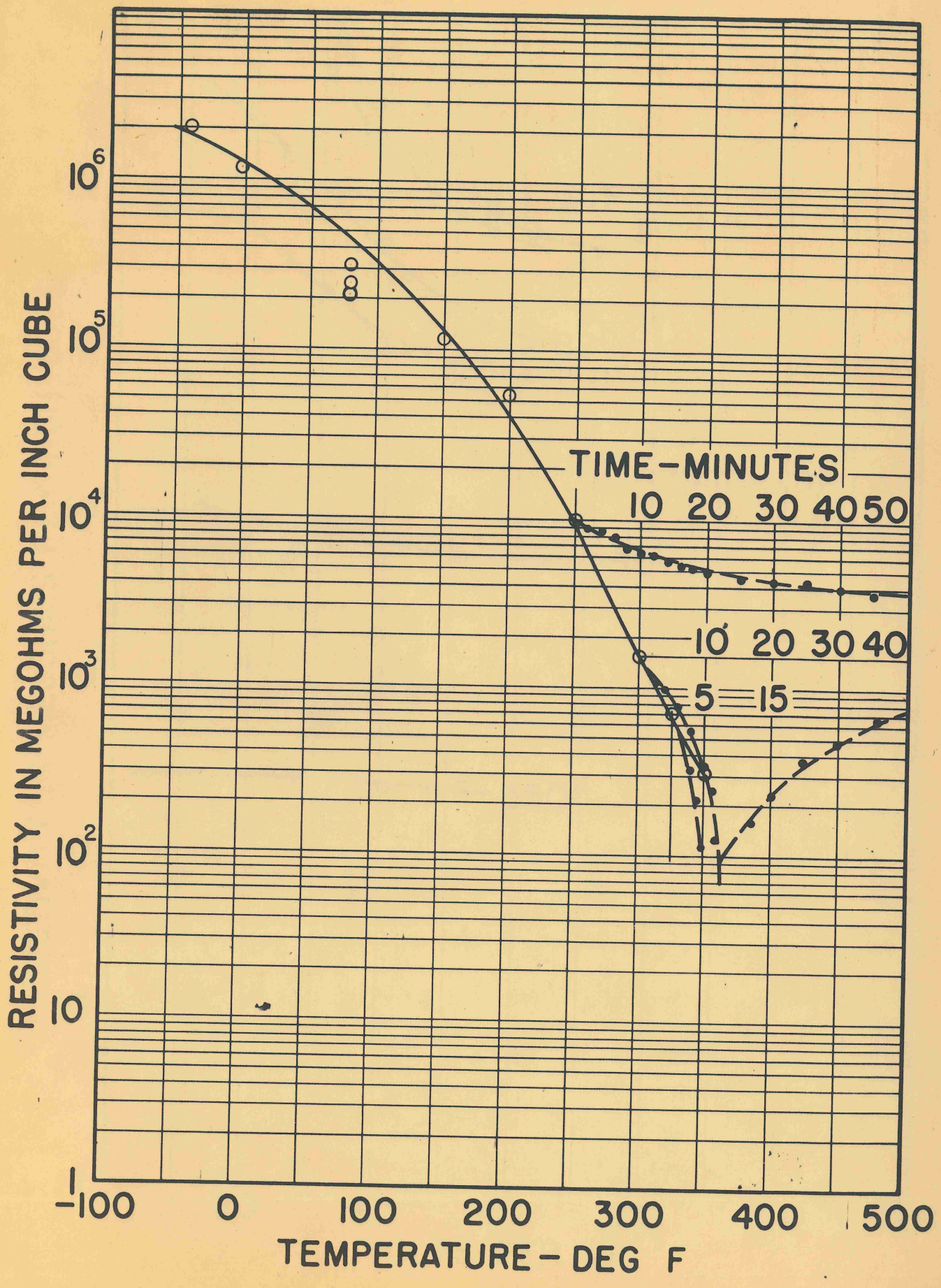


FIG. 2 (FREY & JESATKO)

ELECTRICAL WORLD

A McGraw-Hill Weekly

November 15, 1965

SAVE

DO NOT THROW OUT.

Massive NE Outage
page 44A

EHV • Today's Designs • Tomorrow's Plans

A J PEZDEK
INSULATOR DEPT-GEN ELEC
2525 INSULATOR DR
BALTIMOR ID 21230 C 3

GENERAL ENGINEERING LABORATORY

DIELECTRIC MATERIALS IONIZATION STUDY

for

U. S. NAVY DEPARTMENT BUREAU OF SHIPS

Washington, D. C.

INTERIM ENGINEERING REPORT NO. 2

October 31, 1955

Attention Code 817

Index No.:	NE-111273, Subtask 3
Contract No.:	GE-70779
Customer Order No.:	NOBSR-64657
GE Requisition No.:	W-88882

GENERAL ELECTRIC

Ref:
Bruce Knoblauch

L.J. Stevens
Insulator Dept.
Transformer Div.
General Electric Co.
Baltimore, Md.

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Equipment Testing

GENERAL ELECTRIC
Research Laboratory

CAPACITANCE BRIDGE BALANCER

by

D. A. Felton and P. G. Frischmann

Report No. 56-RL-1616 September 1956

CLASS 2

SCHENECTADY, NEW YORK

JUN 16 1966
RES. LAB. REPRINT 5037

GENERAL ELECTRIC

Research Laboratory

VACUUM ARC RECOVERY PHENOMENA

BY

J. A. RICH and G. A. FARRALL

SCHENECTADY, NEW YORK

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" Kingsbury

~~H A Frey~~
Locke Dept.
Baltimore, Md

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THE ELECTRIC STRENGTH OF SATURATED HYDROCARBON GASES

by

J. C. Devins and R. W. Crowe

Report No. 56-RL-1481 January 1956

CLASS 1

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GENERAL ELECTRIC

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FORMATIVE TIME LAGS IN THE ELECTRIC BREAKDOWN OF LIQUID HYDROCARBONS

by

R. W. Crowe

Report No. 55-RL-1432 November 1955

CLASS 1

SCHENECTADY, NEW YORK

NATIONAL RADIO INSTITUTE

Established 1914

WASHINGTON, D. C.

DISCUSSION SHEET - FOLD AND PLACE WITH LESSON 9FR

There are several places in this lesson where the material is presented in a way that is a decided departure from the conventional manner. For example, we teach you that electromagnetic induction from the primary to the secondary of a transformer is the result of changing flux linkages. While engineers have been talking in terms of flux linkages for years, writers of text books in general have stuck to the old manner of speaking and they talk about conductors cutting lines of force.

Of course we mention this too, but the idea we want you to have after studying this lesson is that changes in flux linkages are responsible for all induced e.m.f.'s. This is all brought out clearly in Figs. 2, 3, 4 and 5. You will notice that we can change the flux linkages in several ways - by moving one of the coils within the other, by moving the larger coil, or by causing the current flowing through one coil to change in magnitude. In any case, there is motion.

Now refer to Fig. 4c. There should of course be a battery in the buzzer circuit. When the switch is closed the buzzer will alternately close and open the circuit and cause the flux about the larger coil to increase and decrease. As the flux moves up and down, its linkages with the smaller coil change and an alternating voltage is induced in the smaller coil.

On page 4 there is a misprint. In the sixth line starting with the last word, change to "The second coil has 100 magnetic lines of force threading through it when maximum current flows in the first coil." On page 6 in the tenth line, we speak of the plate of a tube as a source of e.m.f. You will often see a vacuum tube referred to as a generator of e.m.f. and as the output of the tube is considered as the plate current, the meaning of the sentence will be perfectly clear.

In the seventh line of page 7, change to "lines 1, 2, 3 and 4." Of course, "4" in the next line should be omitted.

Near the bottom of the same page we talk about a complete magnetic circuit. Figure 6b will make clear what is meant. The iron core on which the windings are placed, is closed and the flux can flow right around it, just as current flows in a complete circuit.

In the fourth line of page 9, the statement is made that "The power must be the same." This is true only if there are no losses present in the core. However, there are always some losses so that the output power is always less than the input power. The important thing is that it can't be greater.

On the next page, change 100 in the third and fifth lines to 110 and in the fourth line change 11.5 to 13.6 turns.

The letter L in the fourth line of page 12 refers to the total inductance, including the inductance L1, L2 and the mutual inductance.

On page 15, cross out the whole third sentence under the illustration.

In the eighth line from the bottom of page 19, the printer left out part of the sentence. It should read, "But capacitive reactance shifts phase in a direction opposite to the shift caused by inductive reactance."

On page 24 you will notice the abbreviation μf used twice. This is the same as mfd. In your general reading you will find microfarad abbreviated both ways. On page 28, line fifteen, Fig. C refers to Fig. 21C.

J. A. Dowie, Chief Instructor,
National Radio Institute.

U.S. NAVY
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EXPLANATIONS FOR CODINGS APPLIED TO ATTACHED REQUESTS ARE AS FOLLOWS:

☐ A. Superseded/cancelled not stocked at NSD Phila. Superseded or cancelled items may be requested from: Navy Publications and Printing Service Office, 700 Robbins Avenue, Philadelphia, Pa. 19111.

NOTE: Private industry must submit requests via the contracting officer.

☐ B. Item temporarily not in stock. Will be supplied upon receipt of material (approximately 30 days). No further follow-up required by requester.

☐ C. Since invitations for bid and contracts are not held at this office, documents required cannot be determined without specific document identification numbers. See attached instructions.

☐ D. Item not stocked at NSD, Phila. Request you refer to original source of information for clarification of availability.

☒ E. Researching item availability. Will advise within 5 days.

☐ F. Item is classified. Authority for issue must be endorsed by the cognizant Department of Defense Inspection Office in your area for certification of your "need to know," facility clearance, and storage facilities.

☐ G. Quantity reduced. Maximum of 25 copies allowed.

☐ H. List one item per line. See attached instructions.

☐ I. Item is "for official use only." Request must be submitted via cognizant Department of Defense Inspection Office or your contracting officer for certification of "need to know."

☐ J. Specifications/Standards are not issued in complete sets. See attached instructions.

☐ K. Your request has been referred to office listed below for appropriate action:

- ☐ DEFENSE ELECTRONICS SUPPLY CENTER, 1507 WILMINGTON PIKE, DAYTON, OHIO, 45420
- ☐ COMMANDER, NAVAL SUPPLY SYSTEMS COMMAND (CODE SUP 083) WASHINGTON, D.C., 20360
- ☐ COMMANDER, NAVAL ORDNANCE SYSTEMS COMMAND, WASHINGTON, D.C., 20360
- ☐ COMMANDER, NAVAL SHIP SYSTEMS COMMAND, WASHINGTON, D.C., 20360
- ☐ COMMANDER, NAVAL FACILITIES ENGINEERING COMMAND, WASHINGTON, D.C., 20390
- ☐ COMMANDING GENERAL, AIR FORCE LOGISTICS COMMAND, ATTN: SGEDS, WRIGHT-PATTERSON AFB, DAYTON, OHIO, 45433
- ☐ COMMANDING GENERAL, U.S. ARMY ELECTRONICS COMMAND, 225 S. 18TH ST., PHILADELPHIA, PA., 19103
- ☐ COMMANDING GENERAL, HQ QM R&E CENTER, U.S. ARMY, NATICK, MASS., 01760
- ☐ COMMANDING OFFICER, U.S. NAVAL ORDNANCE PLANT, CENTRAL TECHNICAL DOCUMENT OFFICE, LOUISVILLE, KY., 40214.

☐ L. Items may be purchased from office listed below:

- ☐ SOCIETY OF AUTOMOTIVE ENGR.
  485 LEXINGTON AVENUE
  NEW YORK, NEW YORK, 10017
- ☐ AMERICAN SOCIETY FOR TESTING MATERIALS
  1916 RACE STREET
  PHILADELPHIA, PA., 19103
- ☐ AMERICAN STANDARDS ASSOCIATION, INC.
  10 EAST 40TH STREET
  NEW YORK, NEW YORK, 10016
- ☐ NAT'L STANDARDS ASSOCIATION, INC.
  1321 14TH STREET, N.W.
  WASHINGTON, D.C., 20005
- ☐ NAT'L AEROSPACE STANDARDS COMMITTEE
  AEROSPACE IND. ASS'N OF AMERICA, INC.
  1725 DeSALES STREET, N.W.
  WASHINGTON, D.C., 20036
- ☐ SUPERINTENDENT OF DOCUMENTS
  GOVERNMENT PRINTING OFFICE
  WASHINGTON, D.C., 20370
- ☐ AMERICAN WELDING SOCIETY
  345 E. 47TH STREET
  NEW YORK, N.Y., 10017

☐ M. OTHER

MIL-R-1149A
AMENDMENT - 2
9 June 1961
SUPERSEDING
Amendment - 1
20 May 1958

MILITARY SPECIFICATION

RUBBER SHEETS, STRIPS, AND GASKETS; SOLID, SYNTHETIC, MEDIUM AND MEDIUM HARD

This amendment, which forms a part of Military Specification MIL-R-1149A, 9 April 1956, has been approved by the Department of Defense and is mandatory for use by the Departments of the Army, the Navy and the Air Force.

Page 3, paragraph 3.6.1: Delete and substitute:

"3.6.1 The hardness of the synthetic rubber shall have indentation values within the following ranges. The approximate shore "A" durometer values are included for convenient reference.

Hardness, all classes.

Thickness nominal	Type I		Type II	
	Indentation	Shore "A" durometer	Indentation	Shore "A" durometer
Inch	Millimeters		Millimeters	
1/4	1.12 - 1.42	47 - 56	0.66 - 0.96	62 - 72
5/16	1.14 - 1.44	47 - 55	.68 - .98	61 - 72
3/8	1.16 - 1.46	46 - 55	.68 - .98	61 - 72
7/16	1.18 - 1.48	45 - 54	.70 - 1.00	60 - 71
1/2	1.20 - 1.50	45 - 53	.70 - 1.00	60 - 71

Page 3, paragraph 3.6.2.4: Delete.

Page 3, paragraph 4.1.2, line 2: Delete "inspection" and substitute "examination".

Page 3, paragraph 4.1.2.1, first sentence: Delete and substitute: "For the examination specified in 4.2.1, respresentative samples shall be selected from different portions of each lot in accordance with table III."

FSC 5330

MIL-R-1149A
9 APRIL 1956
SUPERSEDING
JAN-R-1149
27 JUNE 1949

MILITARY SPECIFICATION

RUBBER SHEETS, STRIPS, AND GASKETS; SOLID, SYNTHETIC, MEDIUM AND MEDIUM HARD

This specification has been approved by the Department of Defense and is mandatory for use by the Departments of the Army, the Navy, and the Air Force.

1. SCOPE

1.1 Scope.—This specification covers synthetic rubber compounds for medium and medium hard synthetic rubber gaskets except for hatches, airports, and watertight and airtight doors for shipboard use.

1.2 Classification.—Synthetic rubber shall be of the following types and classes as specified (see 6.1):

Type I—Medium.

Class 1—Compound utilizing polymerized chloroprene as the basic material.

Class 2—Compound utilizing a copolymer product of butadiene and styrene as the basic material.

Class 3—Compound utilizing a copolymer product of isobutylene and isoprene.

Class 5—Compound utilizing a copolymer product of butadiene and acrylonitrile nitrile of the basic material.

Type II—Medium Hard.

Class 1—Compound utilizing polymerized chloroprene as the basic material.

Class 2—Compound utilizing a copolymer product of butadiene and styrene as the basic material.

Class 3—Compound utilizing a copolymer product of isobutylene and isoprene.

Class 5—Compound utilizing a copolymer product of butadiene and acrylonitrile nitrile of the basic material.

2. APPLICABLE DOCUMENTS

2.1 The following specifications and standards, of the issue in effect on date of invitation for bids, form a part of this specification:

SPECIFICATIONS

FEDERAL

NN-B-591	—Boxes, Fiberboard, Wood-Cleated (for Domestic Shipment).
NN-B-621	—Boxes, Wood, Nailed and Lock Corner.
LLL-B-631	—Boxes; Fiber, Corrugated (for Domestic Shipment).
LLL-B-636	—Boxes, Fiber, Solid (for Domestic Shipment).
PPP-B-601	—Boxes, Wood-Cleated-Plywood.
PPP-B-585	—Boxes; Wood, Wirebound.

FED. SUP. CLASS.
5330, 9320

MIL-B-16540A (Wep)
24 May 1961

Superseding
MIL-B-16540 (BuOrd)
17 August 1951

MILITARY SPECIFICATION

BRONZE, PHOSPHOR: CASTINGS

This specification has been approved by the Bureau of Naval Weapons, Department of the Navy

1. SCOPE

1.1 Scope. - This specification covers phosphor bronze sand castings containing a controlled lead content.

1.2 Classification. - Phosphor bronze castings covered by this specification shall be of the following grades (see 6.2):

Grade A
Grade B

1.3 Condition. - Phosphor bronze castings shall be furnished in the "as cast" condition.

2. APPLICABLE DOCUMENTS

2.1 The following specifications, standards and publications, of the issue in effect on date of invitation for bids, form a part of this specification to the extent specified herein:

SPECIFICATIONS

FEDERAL
PPP-B-585 - Boxes, Wood, Wirebound.
PPP-B-601 - Boxes, Wood, Cleated-Plywood.
PPP-B-621 - Boxes, Wood, Nailed and Lock-Corner.

MILITARY
MIL-C-132 - Crate, Wood, Open; Maximum Capacity 2,500 Pounds.

MIL-R-114 A
AMENDMENT - 2

ING
- 1
8

NAVAL SUPPLY DEPOT
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PHILADELPHIA, PA. 19120
OFFICIAL BUSINESS

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NAVY DEPARTMENT

General Electric Co.
Mr. A. L. Libby,
Product Engineer
2525 Insulator Drive
Baltimore 30, Maryland

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SPECIFICATIONS AND STANDARDS REQUISITION

IFB, RFQ OR RFP CLOSING DATE

Send one *copies of the below listed documents which are listed in the DOD Index of Specifications and Standards.*

STANDARDIZATION DOCUMENT SYMBOL	TITLE (From DOD Index of Specifications and Standards)
E — cancelled use	~~QQ-B-637 + QQ-B-639~~
MIL-B-994A	"Phosphor-Bronze"
MIL-B-16541	"Brass"
E — cancelled no superseding number	
MIL-B-1644	"Brass"
JAN-R-1149A	"Neoprene"
MIL-B-16540	"Title Unknown"

Ed 9/8

STA 1 STA 11 STA 13

5

TO: COMMANDING OFFICER
U.S. NAVAL SUPPLY DEPOT
5801 TABOR AVENUE
PHILADELPHIA, PA. 19120

ore "A"
ometer

2 - 72
1 - 72
1 - 72
0 - 71
0 - 71

U.S. 9/13

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SIGNATURE A. L. Libby

Fold

DATE August 29, 1966

DD FORM MAR 65 1425 Stock No. 0101-807-1901

REPLACES 4ND-NSD 5200/1 WHICH MAY BE USED
PLATE NO. 14374

itute

57 te: "For
spresentative samples ... e selected
ccordance with table III."

FSC 5330

QQ-B-637

APRIL 10, 1961

SUPERSEDING
Fed. Spec. QQ–N–35
October 23, 1957
(See section 6)

FEDERAL SPECIFICATION

BRASS, NAVAL: ROD, WIRE, SHAPES, FORGINGS, AND FLAT PRODUCTS WITH FINISHED EDGES (BAR, FLAT WIRE, AND STRIP)

This specification was approved by the Commissioner, Federal Supply Service, General Services Administration, for the use of all Federal agencies.

1. SCOPE AND CLASSIFICATION

1.1 Scope. This specification covers leaded and nonleaded naval-brass rod, wire, shapes, forgings, and flat products with finished edges (flat wire, strip, and bar).

1.2 Classification.

1.2.1 *Compositions.* The naval brass covered by this specification shall be furnished in the compositions shown in table I. Unless otherwise specified in the contract or order, composition 1 shall be furnished.

1.2.2 *Forms and tempers.* The naval brass covered by this specification shall be furnished in the following forms and tempers, as specified (see 6.2):

Form	*Temper*
Bar and rod	As extruded Soft Cold-heading Half-hard or light annealed Hard
Wire	Soft Cold-heading Half-hard or light annealed Hard
Strip and flat wire	Soft Half-hard Hard
Shapes	As extruded Soft Drawn
Forgings	As forged

When temper is not specified, rod, wire, and flat products (flat wire, strip, and bar) shall be furnished in the half-hard temper. Round rod over ½ inch in diameter may be furnished as standard shafting; round rod over 1 inch in diameter may be furnished for special shafting (see 6.2). Shafting is available with or without piston finish (see 3.6).

2. APPLICABLE SPECIFICATIONS, STANDARDS, AND OTHER PUBLICATIONS

2.1 Specifications and standards. The following specifications and standards of the

570405/61/302

FSC 9525
9530
9535
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Maintaining SCIENTIFIC TOLERANCES *by* INSPECTION

By WILLIAM B. RICE

DEPARTMENT OF STATISTICS AND REPORTS, PLOMB TOOL COMPANY, LOS ANGELES, CALIF.

FOLLOWING in the footsteps of Shewhart (1),[1] Simon (2), Wilks (3), and others, the author suggested in a recent article (4) that design tolerances for manufactured products be determined from factual data, analyzed statistically as to:

(*a*) The characteristics required by users of the products.

(*b*) The characteristics of the manufacturing process by which the products are made.

When it has been determined that the process is capable of producing, at a satisfactory cost, a product which meets consumer requirements, the next problem is how to hold the process at the desired level. This is basically an inspection problem.

Before the manufacturer's inspection can succeed in maintaining the characteristics he wants in his product, three requirements must be met:

1 The manufacturer needs to know that his process can be depended upon, that no unpredictable changes occur during production, that he is actually producing what he intends to produce. These requirements can be met only with a statistically controlled process, as evidenced by the use of quality-control charts (5).

2 The manufacturer needs to know that his specifications are practical and profitable, that they will meet consumer demands at a profit to him. A method of meeting this requirement was suggested in the author's previous article (4).

3 The manufacturer needs to know that his inspection procedures are adequate, that from his inspection records he can draw sound and correct conclusions about that part of his product which he does not inspect, in order to be sure that the first and second requirements are being met.

This third requirement is the subject of the present article.

CONCEPTS INVOLVED

Before proceeding with the discussion it seems advisable to give a brief summary of the concepts involved in setting tolerances by statistical methods:

1 Recognition that all things vary and that variability can best be analyzed with statistical techniques. Tolerances should therefore be expressed in statistical terms, such as $\bar{X} \pm t\sigma$, rather than in absolute dimensions such as A, B.

2 Recognition that, in general, no tolerance limits can be set which will always include all pieces produced; that is, tolerances should be considered as probability limits, not absolute limits.

3 Recognition that tolerance limits vary in strictness, depending upon the seriousness of out-of-tolerance work, that more out-of-tolerance work can be permitted for minor defects than for major defects. In other words, specifications may be written $\bar{X} + t\sigma$, $\bar{X} - t'\sigma$, the value of t being different for each type of defect; larger for more serious than for less serious defects.

In the author's previous article (4), an illustration was given of the torque required for an open-end wrench; a "consumer" tolerance of 1500 in-lb, a process capable of holding 2100 in-lb and a design specification of 2000 in-lb, which the process was able to meet and which gave a 33⅓ per cent margin of safety over the consumer requirement.

How should inspection be set up so as to be sure that the wrenches produced are satisfactory? Several possible methods present themselves. Torque tests could be made on every wrench, i.e., 100 per cent inspection; however, such inspection would be not only expensive but also inefficient because unnecessary. With a 33⅓ per cent margin of safety, an occasional failure below the 2000-in-lb specification could be permitted.

Alternatively, sample torque tests could be performed. Assuming lots of 5000 wrenches, with 0.5 per cent defective permitted, the sample would have to be about 1000 pieces out of each lot (6). Such an inspection plan would still be quite expensive and would not give much information except to assure the desired quality level.

Yet another method would be to apply destructive torque tests to a small sample from each lot of 5000 wrenches, the torque being increased until the wrench broke. In this case the sample would have to be quite small for reasons of economy, so small in fact that sound judgments about the remaining wrenches could not be made on the basis of the single small sample.

CONTROL-CHART INSPECTION

All the objectionable features of the methods just proposed can be avoided, and practical certainty of a satisfactory product can be had by adapting the control-chart technique in somewhat the way used by Lieut. Col. Simon at the Aberdeen Proving Ground (2).

Five wrenches from each 1000 can be tested destructively and the readings recorded on control charts (5). As long as the process remains in "statistical control" at a satisfactory level (say, between 2100 and 2400 in-lb), only a small sample of 50 to 100 need be nondestructively tested for conformance to specifications in order to assure satisfactory outgoing quality.

Control charts can simplify and economize inspection procedures in this way because, with a "controlled" process, the manufacturer can be sure that his production methods are turning out a product with consistent characteristics, i.e., with only chance variations; he can be certain that no unknown or unexpected accidents are producing erratic and unpredictable results. Therefore, with this confidence and with the facts revealed by his control charts, he can safely depend upon a mere check test at final inspection.

The design specifications for this wrench should be so written as to provide for the correct inspection procedure. For instance, the upper tolerance limit could be omitted, but the

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

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Information Sciences Laboratory

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by

Dr. S. S. Shapiro, Research and Development Center
Dr. M. B. Wilk, Bell Telephone Laboratories
Mrs. H. J. Chen, Bell Telephone Laboratories

Report No. 65-C-112

December 21, 1965

GENERAL ELECTRIC

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CORPORATE RESEARCH AND DEVELOPMENT
Schenectady, N.Y.

A REVIEW AND COMPARISON OF METHODS FOR REGRESSION ANALYSIS OF CENSORED DATA

by

G. J. Hahn and W. B. Nelson
Information Science and Engineering

Report Number 71-C-196 July 1971

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STUDY OF STATIC AND DYNAMIC SEALS AND SEALING MECHANISMS

EDITED BY

A. J. ORSINO

REPORT NO. 65GL36

MAY 31, 1965

GENERAL ELECTRIC

AIEE
Technical Paper
46-117

May 1946

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THE ELECTRICAL PERFORMANCE OF CERAMIC DIELECTRICS AT ELEVATED TEMPERATURES

H. A. Frey
Member AIEE

J. A. Jesatko
Associate AIEE

Both of:
Locke Insulator Corp.
Baltimore, Md.

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A paper recommended by the AIEE committee on power transmission and distribution for presentation at the AIEE summer convention, Detroit, Mich., June 24-28, 1946. Manuscript submitted March 5, 1946; made available for printing May 8, 1946.

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THE ELECTRICAL PERFORMANCE OF CERAMIC DIELECTRICS AT ELEVATED TEMPERATURES

- o O o -

It is well known that the electrical resistance of most of the commonly used insulating materials diminishes with increasing temperature. The actual performance of ceramic insulating materials at temperatures above the normal atmospheric level, and the factors affecting the ultimate breakdown at these temperatures, has not been the subject of much investigation. Recent requirements for insulators to operate at high temperatures and high voltages have indicated the need for such information.

Apparatus and Method.

It was necessary to provide a suitable test chamber in which the specimens could be mounted and held at any desired temperature while voltage was applied. Accordingly, a thermally insulated box or furnace was built. The electrical heating elements in the back of the box were separated from the test chamber by a one inch thick thermally insulating partition in order to prevent direct heating of the specimens by radiant heat. The heated air was circulated by means of a fan thru ports at each end of the test chamber. The fan also served to maintain air turbulence in the test chamber and thus prevent stratification. Temperature measurements were by commercial gas thermometer and automatic controls were provided for holding any desired temperature between minus 100 degrees Fahrenheit and 1000 degrees Fahrenheit. With this arrangement temperatures could be held within five degrees Fahrenheit of the desired level. Provision was also made for removing the heating elements from the back of the box and substituting racks of dry ice in order to obtain low temperatures.

Most of the tests were made with d-c voltage in order to eliminate the difficulty of separating conduction currents from charging currents. The voltage source was a full wave high voltage kenetron rectifier with suitable capacitors for the elimination of the sixty cycle pulse.

The d-c voltages were measured by means of a suitable known resistance connected in series with a microanmeter.

Most of the test specimens were prepared in the form of plates of various thicknesses. Some specimens were made from standard suspension insulator shells using the head section, ground down to the desired thickness, as the test area.

Electrodes of circular shapes were applied to the opposite sides of each test specimen. Guard rings were also provided to eliminate the effect of surface leakage and corona, and to preserve a more nearly uniform field thru the test zone. The electrodes and guard rings were of silver ceramically bonded to the surface of the dielectric to avoid entrapped air between the dielectric and its electrode.

Porcelain for High Voltage Insulators

In this paper the mechanical failure of porcelain is discussed with special reference to 3 seldom recognized characteristics: the effect of the porcelain surface on the strength, the apparent anomalous distribution of individual mechanical test values, and the effect of time on mechanical strength. A method of evaluating the result of these factors on electrical insulator performance is suggested.

By
D. H. ROWLAND
ASSOCIATE A.I.E.E.

Locke Insulator Corp.,
Baltimore, Md.

THERE CAN BE little argument as to what mechanical characteristics are desirable in high voltage insulators, but the factors which contribute to such characteristics are concealed, more often than not, by an extraordinary amount of sophistic data. Modern high voltage insulators on the average have improved enormously in the past decade. This improvement has been brought about in most cases by expensive and tedious cut and try tests conducted on assembled insulators. The procedure has been to assume that certain features of the completed units such as mechanical strength, ability to withstand immersion first in boiling water and then in ice water, imperviousness to moisture, and other qualities would insure insulators capable of standing up in service, which, after all, is the only real criterion of insulator worth. Finally specifications such as the A.I.E.E. Standards No. 41 for the testing of high voltage insulators were evolved and it may here be stated, unequivocally, that insulators which will successfully pass these specifications will give an unusually good account of themselves in the field. However, just because 2 groups of insulators of different manufacture successfully pass a certain specification it cannot be assumed that their maintenance cost in the field will be the same. How will they stand up under mechanical shock such as the impact from stones or bullets? What effect will time under load have upon their life? What is the maximum load that they will withstand? Is actual experience over a period of years the only way to find out? The purpose of this discussion is to provide engineers with a greater insight into some of the more recently investigated and rather peculiar mechanical characteristics of ceramic materials with the hope that an understanding of this work will help them to answer these questions and to point out that some of the characteristics which have been viewed with alarm by the uninitiated are really a true part of the whole scheme while other factors which have been unknown, or neglected, have been of major importance. A realization of this is bound to lead to still greater efficiency of systems dependent on the insulating qualities of such materials.

A paper recommended for publication by the A.I.E.E. committee on power transmission and distribution, and scheduled for discussion at the A.I.E.E. summer convention, Pasadena, Calif., June 22–26, 1936. Manuscript submitted March 25, 1936; released for publication April 23, 1936.

10. For numbered references see list at end of paper.

Hydro-Quebec

of 200-Mva summer loading, Haberl said. But the 100-ton shipping limit will restrict collector-station units to about 170 Mva.

Despite the industry trend to 3-phase power transformers, V. B. Ross, CGE, told another session, shipping limitations will favor single-phase units for EHV. One reason is the "enormous external phase-to-phase spacing required—27 ft for 700 kv. The problems of designing an economic tank having three bushings each 30 ft long and with adequate clearance to ground are close to being insurmountable."

Weight is saved by using high-temperature insulation, said R. A. Veitch, Canadian Westinghouse, as well as by forced-air cooling and use of grain-oriented steels.

Structures for EHV lines reflect a continuous quest for economy, said V. F. Crowley, Shawinigan Engineering Co. The most recent design, known as the "Y" tower, will be used for the first 50 miles of Ontario Hydro's 500-kv extension south of Sudbury.

In discussion, H. B. White, Alcan, indicated that rather high aluminum Y towers weigh about 61% as much as rigid self-supporting structures, vs 75% for the guyed-V.

Boosts Continental Grid

"We have heard a great deal about the interconnection of transmission systems across Canada," CEA Pres. R. E. Tweeddale told a dinner session. He suggested that concentrated study would show economies in such ties, and "ties across the international boundary would result in a complete transmission grid of the entire continent."

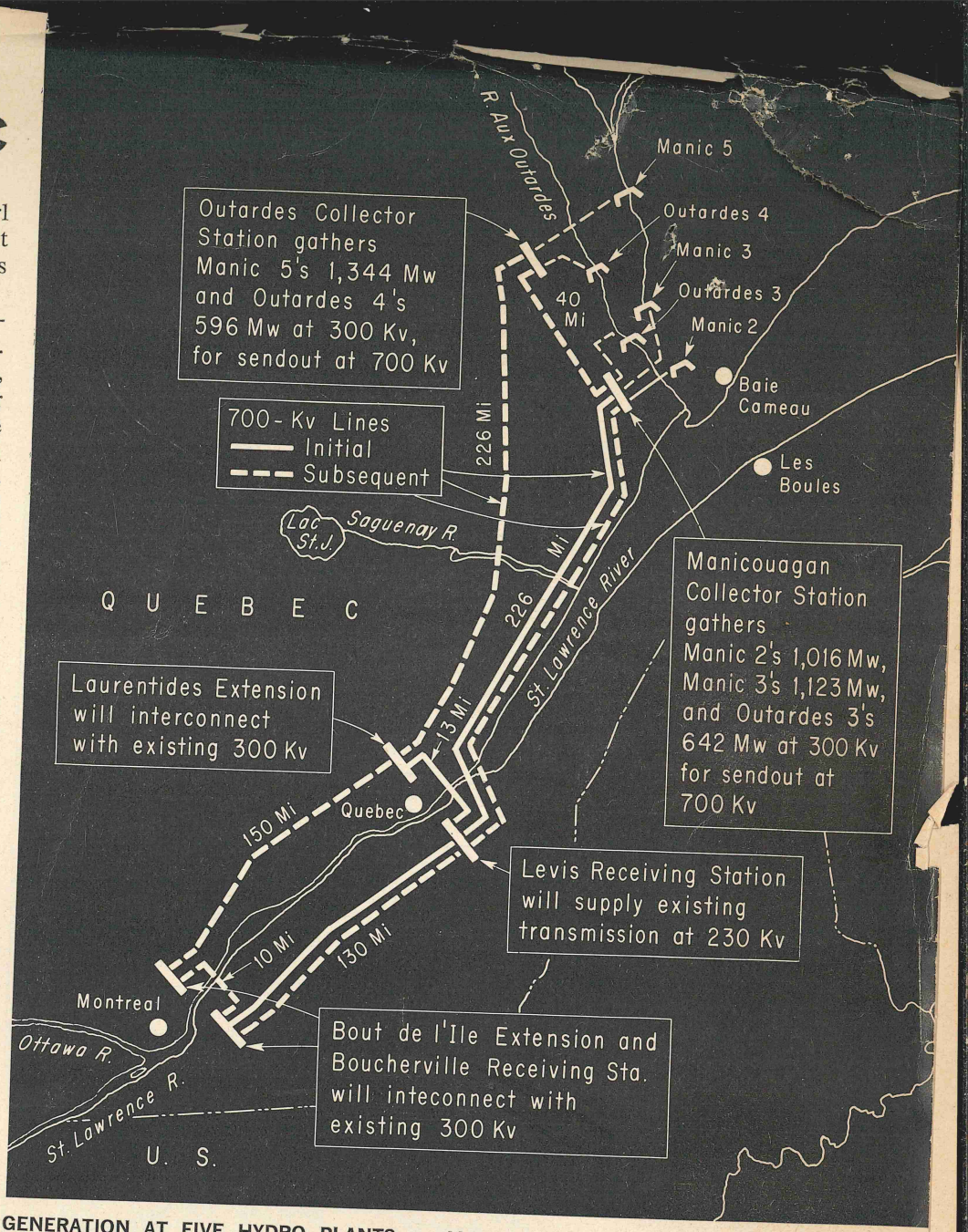
"The recently announced policy change with respect to the export of surplus power to the US will have a very important bearing on the electrical industry in Canada by making possible an accelerated development of our remaining hydro potentials. It is in the national interest", he continued, "to develop these as rapidly as possible."

"A total of 1.6 million kw is available from full development of the St John River," Tweeddale added. "It would involve a large dam in Maine providing downstream regulation for plants in New Brunswick and on-site installation of 700,000 kw. This would require integrated operation between systems in Maine and New Brunswick." But it could be followed, he suggested, by large-scale development of tidal power with interconnections throughout the Maritimes, Quebec, and New England.

Thus Canada has more need for EHV transmission than any other country except possibly Russia, Tweeddale continued, as a continental grid would make her hydro sites valuable for peaking.

At another session, G. A. Ewald, Public Service E&G Co, told of his company's gains from aerial-cable distribution in New Jersey. Outages with the new construction are at a rate less than a fifth those experienced with open-wire, he said, and the cost has averaged only about 3% more.

Original installations were at 4 kv but recent developments have permitted extension to 13 kv, he continued. The higher-voltage system is designed with automatic reclosers and tie switches between adjacent circuits to hold outage exposures to the equivalent of 4-kv circuits and provide service of comparable reliability. Construction of 13-kv circuits generally resembles that developed for 4 kv except that insulation is boosted to 156 mil of butyl rubber and 65 mils of neoprene strung in ceramic spacers.



GENERATION AT FIVE HYDRO PLANTS on Manicouagan and Outardes rivers will be collected via 300-kv links and sent at 700 kv to four receiving stations

700-Kv Transmission Planned for

Canadian Electrical Association told of project to deliver 6,000 Mw to Montreal and Quebec, hears plea for international development of St John River and continental grid

Transmission at 700/735 kv ac was selected by Hydro-Quebec's EHV Project Group as the best way to convey nearly 6 million kw from hydro plants on the Manicouagan and Outardes rivers 400 miles to Montreal, Project Chairman H. W. Haberl told the Canadian Electrical Association recently at Quebec. This voltage was selected, he said, as "the highest . . . possible at this time," considering that manufacturers must start to deliver equipment next year for service in 1965.

Other sessions of the four-day conference covered national and international grids, hydro and thermal generation, overhead and underground distribution, and many other utility subjects.

Backbone of the 700-kv project, Haberl explained, will be three 700-kv lines, two crossing the St. Lawrence near Quebec and following the south shore to a new receiving station at Boucherville, opposite Montreal. The third will run entirely north of the St. Lawrence and terminate at the existing Bout de l'Ile Substation on Montreal Island. All three circuits must also span the 6,000-ft-wide Saguenay.

Boucherville and Bout de l'Ile substations will be linked by a ten-mile 700-kv tie and will deliver Manicouagan power to the existing 300-kv system through nine 600-Mva banks. A similar link near Quebec will link Levis Substation with the third 700-kv circuit and existing 300 kv lines at Laurentides Substation; Levis will have four 400-Mva banks for 230-kv load.

Input to the 700-kv lines will be collected at two transformer stations in the Manicouagan-Outardes area. The first, to be known as Manicouagan because of its proximity to the 1,016-Mw Manicouagan 2, will also gather 1,123-Mw from Manicouagan 3 via four 38-mile lines, 642 Mw from Outardes 3 via two 28-mile lines, and 300 Mw from a later development. All gathering circuits will operate at 300 kv. This station will feed about 3,000 Mw to the two south-shore 700-kv lines.

The other collector station, to be built about 40 miles up the watershed near Outardes 4, from which it gets its name and 596 Mw, will also pick up 1,344 Mw from Manicouagan 5 via four 69-mile 300-kv circuits. Outardes' 2,000-Mw output will flow to Quebec and Montreal via the third 700-kv circuit; it will also have a 700-kv link with Manicouagan Collector Station.

Corona loss will be no greater than that of the existing 300-kv Bersimis lines, Haberl said. Final design will provide four-conductor bundles of the same Bersimis conductor at 18-in. spacing with phase spacings greater than 50 ft. Clearance to steel at each tower must be about 200 in. requiring strings of 35 insulators. Such lines will be rated at 2,000 amp continuous but would be "capable of much more."

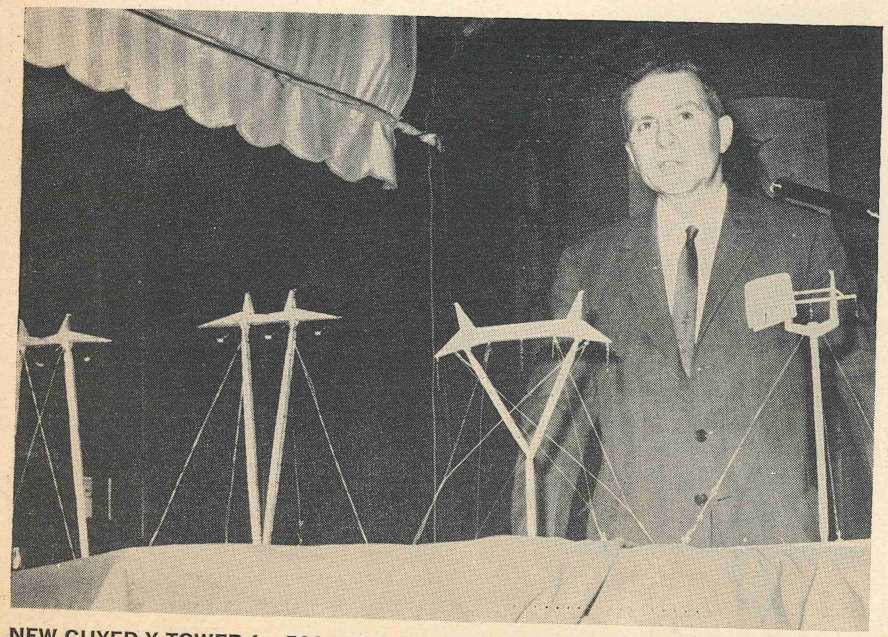
Voltage Limited by Reactors

Overvoltages on lines and equipment will be reduced considerably, Haberl said, by permanently connecting 330-Mva shunt reactors to each 226-mile circuit at the collecting stations and at the receiving stations near Quebec. The shorter lines from Quebec to Montreal will have 165-Mva reactors at each end. Maximum dynamic overvoltage on load rejection, with these reactors, he said, will not exceed 1.5 times normal. Switching surges from line energization are also reduced and will not exceed 2.1 times normal. Consequently, he said, BIL requirements will be 2,000 to 2,500 kv, but without reactors they would be "very difficult."

Total current drawn by the shunt reactors will neutralize two-thirds of line-charging current, he continued, and generators and additional lower-voltage switched reactors will be used to hold down light-load voltage. Switched capacitors on receiving-end 300-kv buses will neutralize shunt-reactor current during full-load operation.

Stability requirements of the 6,000-Mw system will be met by clearing line-to-ground faults in six cycles and reclosing in 25 cycles. The shunt reactors completely discharge the 700-kv line during 25 cycles of dead time, Haberl said.

Power transformers for receiving stations with rail access will be banks of single-phase units capable



NEW GUYED-Y TOWER for 500-kv lines (second from right) is compared with more conventional guyed structures by V. F. Crowley, Shawinigan Engineering Co.

GENERAL ENGINEERING LABORATORY

TC-2C AND TC-15 MEETINGS - VÄSTERÅS, SWEDEN 1958

by

K. N. Mathes

Report No. 58GL332

December 5, 1958

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FN-412-A (2-55)

EXTRA HIGH VOLTAGE TRANSMISSION

IN THE

CENTRAL STATES REGION

REPORT NO. 1

R.D. Webster
General Electric Company
Chicago Office
January 2, 1964

GENERAL ELECTRIC

RESEARCH AND DEVELOPMENT CENTER

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CLASS 1

THEORY OF THE TENSILE TEST

by

E.W. Hart, Metallurgy and Ceramics Laboratory

Report No. 66-C-222 June 1966

DF52GL117

DMD
BEA
This would be of interest
if it doesn't cost too much
Bfm

Equipment Testing

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General Engineering Laboratory

AN ADJUSTABLE RATE OF RISE CONTROL SYSTEM FOR DIELECTRIC STRENGTH TESTING

By

R. N. Bushman

SCHENECTADY, NEW YORK

AIEE
Technical Paper
51-240

May 1951
Litho in USA

Equipment - Testing

SOME ENGINEERING APPLICATIONS OF THE ELECTROLYTIC FIELD-ANALYZER

H. K. Farr
Member AIEE
General Electric Company,
Pittsfield, Mass.

W. R. Wilson
Member AIEE
General Electric Company,
Philadelphia, Pa.

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Dielectrics

GENERAL ELECTRIC

Research Laboratory

PULSE MEASUREMENT TECHNIQUES FOR THE STUDY OF SECONDARY ELECTRON-EMISSION PROPERTIES OF INSULATORS

by

A. B. Laponsky and N. R. Whetten

Report No. 56-RL-1660 November 1956

CLASS 1

SCHENECTADY, NEW YORK

Dielectrics

TECHNICAL INFORMATION SERIES

TECHNICAL INFORMATION SERIES
Title Page

AUTHOR	SUBJECT CLASSIFICATION	NO.
R.E. Plump T. W. Liao	Gaseous Insulation	57TP517
		DATE 2/14/58

TITLE

Progress in Gaseous Insulation

FOR USE OF G-E EMPLOYEES ONLY

GENERAL ELECTRIC

TRANSFORMER AND ALLIED PRODUCTS DIVISION

TA-809-T (8-52)

FOR USE OF G-E EMPLOYEES ONLY

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TECHNICAL INFORMATION SERIES

Title Page

AUTHOR	SUBJECT CLASSIFICATION	NO.
R.E. Plump T. W. Liao	Gaseous Insulation	57TP517
		DATE 2/14/58

TITLE

Progress in Gaseous Insulation

ABSTRACT Theoretical, experimental, and practical developments in gaseous dielectric phenomena are reviewed from recent literature. Chemical and physical properties of gases and their effects, are also discussed. (113 references.) The report was originally written for Heywood & Co. of London as a chapter for a book on Progress in Dielectrics.

G.E. CLASS	REPRODUCIBLE COPY FILED	NO. PAGES
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GOV. CLASS		33
None	Pittsfield Data Bureau	

CONCLUSION

Interest in gaseous insulation is world-wide, and much progress has been made in the past decade.

Areas in this field include rotating machinery, power apparatus, switchgear, cables, etc. Theoretical and experimental advances have been made toward more understanding of the requirements of particular applications. A distinction between electronegative gases and all others appears to be firmly established. Lighter gases such as hydrogen and helium still retain much usefulness for heat transfer in rotating machinery, but the chemistry and physics of heavier gases are favorable for many other applications.

By cutting out this rectangle and folding on the center line, the above information can be fitted into a standard card file.

For list of contents-drawings, photos, etc. and for distribution see reverse side.

INFORMATION PREPARED FOR General Information

TESTS MADE BY

COUNTERSIGNED SECTION

BUILDING and ROOM No. 9 - 202 (Liao) 8 - 509(Plump) LOCATION Pittsfield, Massachusetts

Mr. Vadnagara requests additional information as to the capacitance of the test circuit for the current-limiting fuses. The normal test circuit would have an inherent shunt capacitance of several thousand picofarads, the exact amount depending on whether high-voltage transformers with capacitance graded bushings, actual length of buswork, and impedance loading were used. This capacitance would be in the range of normal overhead distribution.

Typical installations using underground cable would have a shunt capacitance of much higher value. These values could range from 0.1 to 0.5 μF. Since the normal test setup does not utilize any shunt capacitance of these values, a special test was made to determine whether it would be an appreciable factor. One size (15.5 kV 10 amperes) NX fuse was tested on a circuit with an available fault current of 12 kA at the fuse design voltage. A shunt capacitance (in addition to the normal circuit capacitance) was varied from 0.075 to 0.53 μF during the test sequence. The peak arc voltage was found to be slightly higher (2.5 to 5 percent) with the larger shunt capacitance value than the maximum obtained with no added shunt capacitance. I would attribute this to a slight interaction between the circuit inductance and the shunt capacitance when the fuse element melts and introduces a rapid resistance into the circuit; but the same resistance quickly dampens any oscillatory effects and prevents higher overshoot of the voltage.

Mr. Bronikowski's supposition regarding the use of ribbon-element NX fuses at lower circuit voltages with a corresponding reduction of maximum arc voltage is correct. Also, with this type of element, the maximum arc voltage remains independent of the fault current. This characteristic permits more versatility of application as Mr. Bronikowski mentions, especially as related to coordination with lightning arresters.

Testing EHV Station Insulation for Performance in Contaminated Conditions

JAMES D. M. PHELPS, MEMBER, IEEE, JAMES B. OWENS, SENIOR MEMBER, IEEE, AND AREM FOTI, SENIOR MEMBER, IEEE

Abstract—This technical paper deals with two phases of wet testing of EHV station insulators; one for conventional rainfall tests with prescribed rate of precipitation and water resistivity and the other for artificial contamination or pollution tests under wet conditions. The authors recommend a change in USA Standards for rate of precipitation and resistivity of water and offer supporting test data confirming the ability to distinguish between satisfactory and unsatisfactory insulator designs as a result of employing their new proposal. They also offer a proposed contamination test procedure which is convenient to use, which gives reproducible results, and which is sufficiently flexible for use in varying the severity of the applied artificial contaminant according to user requirements. The artificial contamination, or pollution, test may be used in rating insulator designs concerning performance under contaminated and wet conditions.

Introduction

INSULATION systems for outdoor stations have traditionally been designed using stacking apparatus insulators. Porcelain elements with appropriate joining hardware have been assembled into columns to provide adequate height and insulation performance. When insulation systems have been designed for extra high voltage (EHV) stations rated 345 kV and higher, it has been observed that incremental increases in the height of insulator columns do not produce a corresponding or proportionate increase in the insulating value achieved. This is particularly true when insulation is subjected to long-duration switching surge voltages. Extra care in testing and evaluation of test information has been required to insure the desired reliability of EHV station insulation performance.

In the design of 500- and 765-kV stations for operation in coastal or industrial environments, it is particularly important that insulation performance be evaluated with a proper simulation of the variety of conditions that will exist in service. Consideration must be given to the effects of rain, fog, and moisture condensation on clean and contaminated insulator surfaces.

Tests have been conducted leading to the establishment of new performance criteria for wet testing to evaluate insulation performance during rainfall conditions. In addition, work has been done to develop a technique for the simulation of heavy surface contamination wetted by fog or mist. The work was undertaken because there was no recognized system of evaluation from which reliable and repeatable results could be obtained and related to field experience.

Wet or Rain Testing

The current standards of the U.S.A. Standards Institute[1] specify that outdoor station apparatus insulators be subjected to a wet test using water of 17 800 ohm-cm resistivity falling at a rate which will allow an accumulation of 5.08 mm/min. The standards of the International Electrotechnical Commission (IEC)[2] specify that wet testing be conducted with 9000–11 000 ohm-cm water and a rainfall rate of 3 mm/min. These are exceedingly heavy rates, corresponding to an accumulation of 7–12 inches per hour or 17–29 feet per day. Such rates of rainfall rarely, if ever, occur in outdoor station operating environments.

The resistivity of the water specified in the U.S.A. standards is substantially higher than the resistivity of rain water that has fallen through normal city or industrial atmospheres during the early portion of rain incidents.[3] IEC requirements more closely

Paper 31 TP 67-98, recommended and approved by the Switchgear Committee of the IEEE Power Group for presentation at the IEEE Winter Power Meeting, New York, N. Y., January 29–February 3, 1967. Manuscript submitted October 31, 1966; made available for printing August 30, 1967.

J. D. M. Phelps is with the American Electric Power Service Corporation, Canton, Ohio.

J. B. Owens and A. Foti are with the I-T-E Circuit Breaker Company, Greensburg, Pa. 15601

TRANSMISSION SYSTEM CONTAMINATION SYMPOSIUM

September 22 and 23, 1969
Holiday Inn, Lenox, Mass.

OBJECT: To allow interested General Electric Departments an opportunity to discuss common and individual problems with respect to increasing contamination consideration by our customers and standardizing bodies.

September 22, 1969

2:00 P.M.	Meet for coffee at the High Voltage Laboratory (Bldg. 9)
2:15 P.M.	Demonstration of flow-on method of contamination testing - HVL.
3:00 P.M.	Tour of outdoor research area of HVL.
3:45 P.M.	Tour of Project UHV facilities - Lenox.
5:30 P.M. - 6:30 P.M.	Informalities at the Holiday Inn.
6:30 P.M.	Dinner (Dutch Treat)

September 23, 1969 - Holiday Inn, Lenox, Mass.

8:30 A.M.	Welcome	A. Glassanos, Mgr. Engr. Power Transformer Dept.
8:45 A.M.	Test Methods and Standards for Contamination	G.W.Alexander - Mgr.HVL Power Transformer Dept.
	High Voltage Techniques for Testing	F.J.Turner - HVL
	Correlation of Test Methods with Natural Contamination	M. Kawai - Project UHV
	Standardization Activities in NEMA, IEEE, IEC, CIGRE	J.G.Anderson A.F.Rohlfs Dr. T.W.Liao
10:00 A.M.	Coffee Break	
10:15 A.M.	Design of Apparatus to Withstand Contamination	J.G.Anderson - Mgr. Project UHV - Electric Util. Engr. Opr.
	Lightning Arresters	E.C.Sakshaug
	Bushings	J.K.Easley
	Power Circuit Breakers	C.M.Ratliff
	Instrument Transformers	
	Power Line Carrier Current Equpt.	

A L Libby

INSULATOR CONTAMINATION - PROBLEMS AND TESTS

F. J. Turner

I. INTRODUCTION

II. GENERAL PROBLEMS

A. To Simulate or Not to Simulate Nature

B. Measurements of Degree of Contamination

C. Selection of Contamination Materials CONDUCTIVITY MATTERS MOST

D. Method of Moisture Application - REPEATABILITY

III. POPULAR PRESENT DAY CONTAMINATION TEST METHODS

A. Salt Fog Test - DEVELOPED IN ENGLAND

B. Predeposit Test

1. German method

2. Dipping method

3. Flow-coating

C. ASEA Test Method

D. Wet Contaminant Method

IV. SUMMARY

A. Utility of Various Test Methods

B. Correlation With Natural Conditions

C. Need for Both Development & Practical Test Methods

TRANSMISSION SYSTEM CONTAMINATION SYMPOSIUM

September 22 and 23, 1969
Holiday Inn, Lenox, Mass.

OBJECT: To allow interested General Electric Departments an opportunity to discuss common and individual problems with respect to increasing contamination consideration by our customers and standardizing bodies.

September 22, 1969

2:00 P.M.	Meet for coffee at the High Voltage Laboratory (Bldg. 9)
2:15 P.M.	Demonstration of flow-on method of contamination testing - HVL.
3:00 P.M.	Tour of outdoor research area of HVL.
3:45 P.M.	Tour of Project UHV facilities - Lenox.
5:30 P.M. - 6:30 P.M.	Informalities at the Holiday Inn.
6:30 P.M.	Dinner (Dutch Treat)

September 23, 1969 - Holiday Inn, Lenox, Mass.

8:30 A.M.	Welcome	A. Glassanos, Mgr. Engr. Power Transformer Dept.
8:45 A.M.	Test Methods and Standards for Contamination	G.W.Alexander - Mgr.HVL Power Transformer Dept.
	High Voltage Techniques for Testing	F.J.Turner - HVL
	Correlation of Test Methods with Natural Contamination	M. Kawai - Project UHV
	Standardization Activities in NEMA, IEEE, IEC, CIGRE	J.G.Anderson A.F.Rohlfs Dr. T.W.Liao
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	Power Line Carrier Current Equpt.	

Transactions Paper

(Reviewed and Accepted for Publication)

DISCUSSION IN QUADRUPLICATE DUE February 14, 1969.

A NEW CONTAMINATION TEST METHOD

B. Macchiaroli
Inst.of Electrical Engineering
University of Naples
Naples, Italy.

F. J. Turner
Senior Member IEEE
General Electric Company
Pittsfield, Mass.

A paper recommended by the IEEE Transmission & Distribution Committee of the IEEE Power Group for presentation at the IEEE Winter Power Meeting, New York, N.Y., January 26-31, 1969. Manuscript submitted September 17, 1968; made available for printing October 23, 1968.

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69 TP 14 - PWR

Transactions Paper

(Reviewed and Accepted for Publication)

DISCUSSION IN QUADRUPLICATE DUE July 11, 1969.

A STUDY OF SOME VARIABLES AFFECTING CONTAMINATION TESTING USING THE WET CONTAMINANT METHOD

B. Macchiaroli
Institute of Electrical Engineering
University of Naples
Naples, Italy.

F. J. Turner
Senior Member IEEE
General Electric Company
Pittsfield, Mass.

A paper recommended by the IEEE Transmission and Distribution Committee of the IEEE Power Group for presentation at the IEEE Summer Power Meeting, Dallas, Texas, June 22-27, 1969. Manuscript submitted February 17, 1969; made available for printing April 15, 1969.

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69 TP 692 - PWR

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INSULATOR CONTAMINATION - PROBLEMS AND TESTS

F. J. Turner

I. INTRODUCTION

II. GENERAL PROBLEMS

- A. To Simulate or Not to Simulate Nature
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- D. Wet Contaminant Method

IV. SUMMARY

- A. Utility of Various Test Methods
- B. Correlation With Natural Conditions
- C. Need for Both Development & Practical Test Methods

FIELD AND LABORATORY TESTS OF CONTAMINATED INSULATORS FOR THE DESIGN OF THE STATE ELECTRICITY COMMISSION OF VICTORIA 500 KV SYSTEM

J. Johnson* R. T. Henderson* W. S. Price**

D. E. Hedman*** F. J. Turner ****

In recent years, the control of switching surges by circuit breaker resistors, and the use of shielding angles adequate to reduce lightning impulse flashovers, has made possible appreciable reduction in transmission line insulation levels and cost, particularly on EHV lines. As this process continues, additional design data will be required for the power frequency withstand of line insulators exposed to contamination, if future line designs are to be both successful and economical.

Although extensive investigations have been made during the past two decades on the power frequency performance of contaminated insulators, the basic mechanism is so complex, and there are so many parameters, known and unknown, in the problem that much work remains to be done to permit optimum line design.

Since the future 500 kv transmission system of the State Electricity Commission of Victoria must traverse a very severe contamination area, as indicated by present 220 kv line performance, a very extensive investigation has been made, including both field and laboratory work. This work provided a substantial amount of new design information for the 500 kv system. Details of this study are presented in this paper, for comparison with previous investigations, and possibly to serve as a basis for future research.

FIELD EXPERIENCE

The State Electricity Commission of Victoria supplies virtually all the electric power in the State of Victoria, an area of some 88,000 square miles in the southeastern corner of Australia. Apart from small hydroelectric stations contributing to peak load demands, and a low load factor entitlement from the Snowy Mountains Scheme, the bulk of the power is generated by base load thermal stations situated on the very extensive lignite brown coal fields of the Latrobe Valley, about 90 miles east of the capital city of Melbourne.

Since the first thermal station was installed in 1924, the total capacity of the Latrobe Valley generation has grown to its present level of some 1,400 MW, with a further 1,700 MW of plant under construction or on order, and the probability of extensive additions in the future.

* State Electricity Commission of Victoria, Melbourne, Australia.
** Bechtel Corporation, San Francisco, California.
*** General Electric Co., Schenectady, New York.
**** General Electric Co., Pittsfield, Massachusetts.

INSULATOR BEHAVIOR IN CONTAMINATED ATMOSPHERES

F.J.Turner
Senior Member IEEE
General Electric Co.
Pittsfield, Mass.

M.Kawai
Member IEEE
General Electric Co.
Pittsfield, Mass.

J.Kaminski, Jr.
Senior Member IEEE
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STANDARDIZATION OF POLLUTION TESTS IN IEC TC 42

IEC TC 42, High Voltage Testing Techniques, has adopted the following clauses for contamination testing. These have been approved to be sent out to the National Committees under the six-months rule.

3.4 Artificial pollution tests

Artificial pollution tests are intended to provide information on the behaviour of external insulation under conditions simulating pollution in service.

The basic objective is usually to verify that the test object will withstand a specified amount of pollution at a given test or operating voltage.

For comparison tests and for research, the objective may be either to determine the degree of pollution that the test object can withstand with a given probability at a given test voltage, or to determine the withstand voltage for a specified degree of pollution. For comparison tests, the former procedure is preferable.

The procedure to be adopted must give reproducible results, taking into account the statistical nature of the flashover mechanism.

The result of an artificial pollution test is dependent mainly on the following factors:

- the installation of the test object
- the procedure for applying the pollution
- the amount, conductivity and distribution of the pollution
- the amount of moisture deposit
- the manner in which the test voltage is applied.

3.4.1 Test procedures

3.4.1.1 Installation

The test object should be tested in a position (horizontal, vertical or inclined) corresponding to actual working conditions. The clearance to entraneous structures (see Clause 3.1) need not exceed 1.0 S and may even be reduced below this, without affecting the validity of results, provided risk of flashover of the clearance is avoided.

The insulator shall be in thermal equilibrium with the air in the chamber at the start of the test. The ambient temperature at the start of the test shall be not less than 5°C or greater than 30°C.

Survey of Literature in 1968
by W.T. Starr

The state of understanding of the mechanism of flashover of polluted insulation is revealed by Zoledziowski's paper [1], and the discussion following it. Z. fits his data to the equation $(V^2-V_o^z)t = \frac{Ce}{3} r^2 L^3$ where V is the applied unidirectional voltage, V_o is the minimum voltage below which a flashover will not occur, t is the time to flashover, C is a constant, e is the energy needed for discharge production, r is the pollution resistance per unit length, and L is the distance between electrodes. Zoledziowski believes that the discharge propagates in air, not steam, that a dry band is not required for discharge initiation, and that the discharge starts to propagate at zero time.

Salthouse [2] has studied the processes which result in the initiation of dry bands on polluted insulators. Above a critical temperature rise (ΔTc) which is less than 1°C, the resistance in one location increases much more rapidly than in others. ΔTc corresponds to a power dissipation density of about 5mW/cm^2.

Kawai[3] has studied the natural conditions of humidity, fog and temperature which precipitate flashover and has determined withstand voltage of a variety of types of suspension insulators as a function of salt deposit density. Light rain or fog after several hours of high humidity minimizes flashover voltage. A steam fog artifically reproduces this condition.

Johnson et al[4] have reported on an intensive study of the conditions leading to flashover of heavily contaminated insulator strings leading to design criteria for a 500 kV line in Victoria. Contamination is by a salt laden smoke and fog, underside contamination controls. KV/insulator for 60 Hz flashover varies linearly with the logarithm of salt concentration being 1.3 in/Kv at 0.2 and 2.1 in/KV at 10 mg/cm^2. A mechanism is suggested and results of high speed motion picture corollation with surging currents are described.

Conference Paper

COMPARISON OF INSULATOR TYPES

BY THE

WET CONTAMINANT AND CLEAN FOG TEST METHODS

B. Macchiaroli
Inst. of Electrical Engineering
University of Naples
Naples, Italy

F. J. Turner
Senior Member IEEE
General Electric Company
Pittsfield, Massachusetts

Paper No.
69 CP 176 - PWR

CABOT CORPORATION 125 HIGH STREET, BOSTON, MASSACHUSETTS 02110

CABLE ADDRESS "CABLAK" BOSTON
TEL. 617 423-6000

September 22, 1969

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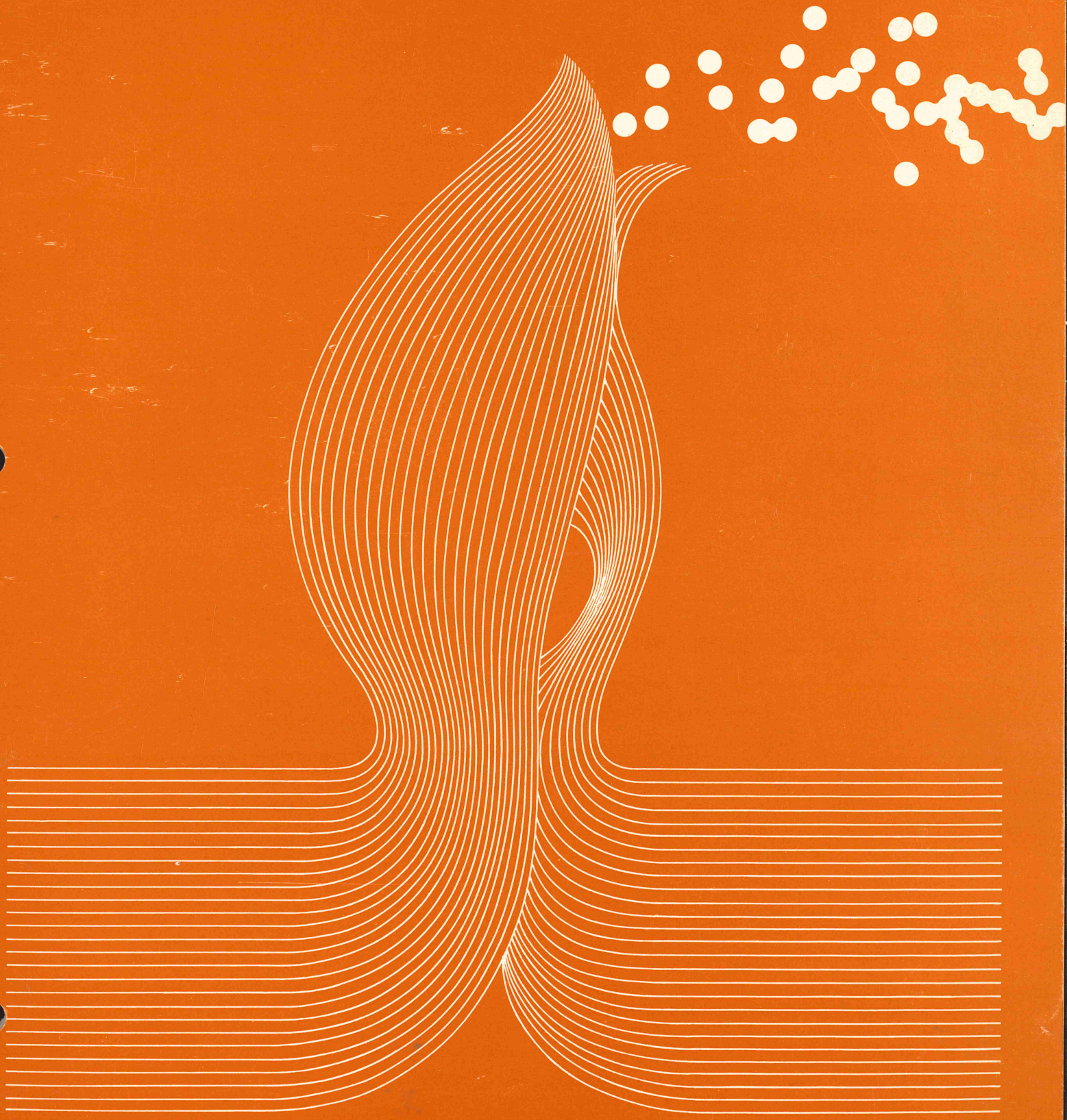

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A NEW CONTAMINATION TEST METHOD

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MEMORANDUM

August 21, 1969

PROCEDURE FOR CONDUCTING CONTAMINATION TESTS ON SUSPENSION INSULATORS

A. GENERAL

At the present time there is a great need for an artificial contamination test for high voltage suspension insulators for use in polluted areas. In such areas the behavior of suspension insulators is frequently the limiting factor in determining the size and type of insulator to be used.

B. WITHSTAND VOLTAGE TEST

The object of this test is to determine the maximum withstand voltage at a given reference layer conductivity. A series of testsshall be conducted as prescribed in this memorandum on an insulator, or insulators, with specified reference coatings. The insulator withstand voltage is the maximum value of voltage which may be applied to a test specimen on three consecutive trials without flashover at a given level of layer conductivity.

C. SCOPE OF TESTS

1. The procedure outlined in this memorandum applies to the testing of porcelain suspension insulators of nominal voltages greater than 1 KV, which are used outdoors and exposed to polluted atmospheres. At present, this procedure is limited to A.C. voltage tests, and is not intended to be used for insulators of organic material or to determine the efficiency of different surface treatments, such as silicone compounds. The general procedure is known as the wet-contaminant method and is generally in agreement with that described by F. J. Turner and B. Macchiaroli.[1]

   The voltage source used in making these tests should have a short circuit current not less than 5 amperes RMS.

2. Cleaning of Insulators

   The insulators shall be carefully cleaned so that all traces of grease are removed. Detergent may be used, after which the insulator surface shall be thoroughly rinsed with clear water to remove remaining traces of any ionizing material. The surface of the insulator is deemed sufficiently clean and free from any grease if large continuous wet areas are observed. After washing, insulators shall be dried by blowing compressed air on the surfaces.

[1] IEEE Paper No. 69-TP-692 "A Study of Some Variabiles Affecting Contamination Testing Using the Wet Contamination Method" B. Macchiaroli and F. J. Turner.

IEEE Paper No. 69-TP-14 "A New Contamination Test Method" B. Macchiaroli and F. J. Turner.

AIEE
Technical Paper
51-312

July 1951
Litho in USA

Equip. - Testing

TRAVELING WAVE RELATIONS APPLICABLE TO POWER-SYSTEM FAULT LOCATORS

Laurel J. Lewis
Member AIEE
University of Washington
Seattle, Wash.

Advance Copy
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33 West 39th Street, New York 18, N.Y.

A paper recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, Portland, Oregon, August 20-23, 1951. Manuscript submitted May 22, 1951; made available for printing July 10,1951.

PRICE: 30¢ To Members
60¢ To Nonmembers

FINAL REPORT

PHYSICAL PROCESSES IN CONTAMINATION FLASHOVER OF HIGH VOLTAGE INSULATION

June 1975

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SCHOOL OF ENGINEERING 617 253-4630

ELECTRIC POWER SYSTEMS ENGINEERING LABORATORY

CAMBRIDGE, MASSACHUSETTS 02139

Room 7-005

May 5, 1975

To Locke

For your reference

TO: Members of the Contamination Working Group

On May 30, 1975 MIT will host an informal seminar on contamination flashover. Interested members of the Working Group as well as other interested persons are welcome to attend. The major purpose of the seminar will be to present results of the NSF sponsored flashover study.

The presentation will include:

1) Presentation of theoretical results.

→ 2) Presentation of methods found to control flashover, including one method for which a patent has been filed. High speed motion pictures of these methods preventing flashover will be shown.

→ 3) A discussion of surface wetting effects.

→ 4) Results of tests on semiconducting glaze units.

5) A demonstration of a computer simulation of flashover.

6) A tour of the laboratory, and flashover demonstrations.

→ In connection with the topic of surface wetting, Mr. Tom Kell, President of Silibond Products, Inc. will discuss a new water repellant coating for insulators. It is far more repellant than Teflon or Silicone. The coating is in the development stage and has been successfully tested at MIT. A coated suspension insulator will be available for inspection.

Also participating in the presentation will be Mr. Ed Los of the G.E. High Voltage Laboratory, and hopefully Professor T.C. Cheng of the University of Southern California, who conducted research while a student here, and is now carrying out contamination research at USC.

The meeting will be from 9:00 a.m. to about 4:00 p.m. Reservations should be made directly with one of the hotels listed on the attached sheet. The Hotel Sonesta is recommended as being near MIT, but may fill up shortly.
The meeting has been scheduled on Friday so that persons so desiring can spend a weekend in the Bicentennial City. For those who think they are young enough, we hope to have an optional "night on the town" after the Seminar.

Please let us know if you plan to attend so that we can plan ahead and also send further details.

D Jolly

David C. Jolly
Staff Engineer
Division of Sponsored Research

DCJ/s
enc:

MAY 7 1975